

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
18 October 2001 (18.10.2001)

PCT

(10) International Publication Number  
**WO 01/77115 A1**

(51) International Patent Classification<sup>7</sup>: **C07D 515/22**,  
A61K 35/00, 35/56 // (C07D 515/22, 317:00, 291:00,  
241:00, 221:00)

(21) International Application Number: PCT/GB01/01667

(22) International Filing Date: 12 April 2001 (12.04.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:  
0009043.1 12 April 2000 (12.04.2000) GB  
PCT/GB00/01852 15 May 2000 (15.05.2000) GB  
0022644.9 14 September 2000 (14.09.2000) GB

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(81) Designated States (*national*): AE, AG, AL, AM, AT, AU,  
AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU,  
CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM,  
HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK,  
LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX,  
MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL,  
TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

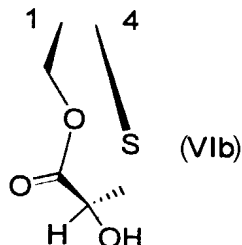
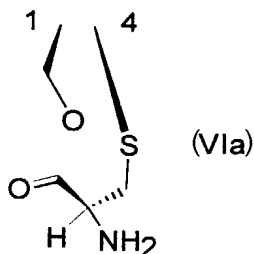
(84) Designated States (*regional*): ARIPO patent (GH, GM,  
KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian  
patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European  
patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE,  
IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF,  
CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

**Published:**

— with international search report

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

(54) Title: ANTITUMORAL ECTEINASCIDIN DERIVATIVES



(57) Abstract: Compounds having a fused ecteinascidin five ring system with a 1,4 bridge having the structure of formula (VIa or VIb) and compounds in which the -NH<sub>2</sub> or -OH of the 1,4 bridge is derivatised are disclosed. Such compounds are useful in the treatment of tumours.

## ANTITUMORAL ECTEINASCIDIN DERIVATIVES

The present invention relates to antitumoral ecteinascidin derivatives.

## BACKGROUND OF THE INVENTION

The ecteinascidins are exceedingly potent antitumour agents isolated from the marine tunicate *Ecteinascidia turbinata*. Several ecteinascidins have been reported previously in the patent and scientific literature.

U.S. Patent N° 5,256,663 describes pharmaceutical compositions comprising matter extracted from the tropical marine invertebrate, *Ecteinascidia turbinata*, and designated therein as ecteinascidins, and the use of such compositions as antibacterial, anti-viral, and/or antitumour agents in mammals.

U.S. Patent N° 5,089,273 describes novel compositions of matter extracted from the tropical marine invertebrate, *Ecteinascidia turbinata*, and designated therein as ecteinascidins 729, 743, 745, 759A, 759B and 770. These compounds are useful as antibacterial and / or antitumour agents in mammals.

U.S. Patent N° 5,478,932 describes ecteinascidins isolated from the Caribbean tunicate *Ecteinascidia turbinata*, which provide *in vivo* protection against P388 lymphoma, B16 melanoma, M5076 ovarian sarcoma, Lewis lung carcinoma, and the LX-1 human lung and MX-1 human mammary carcinoma xenografts.

U.S. Patent N° 5,654,426 describes several ecteinascidins isolated from the Caribbean tunicate *Ecteinascidia turbinata*, which provide *in vivo* protection against

P388 lymphoma, B16 melanoma, M5076 ovarian sarcoma, Lewis lung carcinoma, and the LX-1 human lung and MX-1 human mammary carcinoma xenografts.

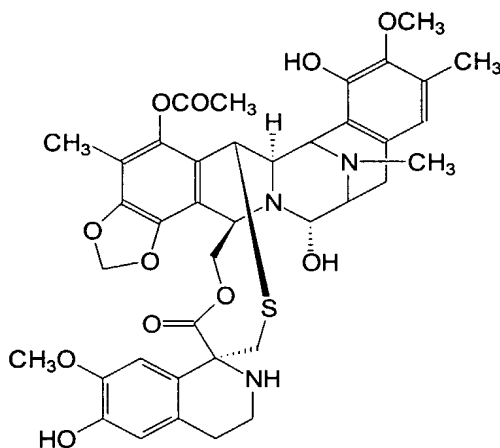
U.S. Patent N°. 5,721,362 describes a synthetic process for the formation of ecteinascidin compounds and related structures.

WO 00/69862, from which the present application claims priority, describes the synthesis of ecteinascidin compounds from cyanosafracin B.

The interested reader is also referred to: Corey, E.J., J. Am. Chem. Soc., 1996, 118 pp. 9202-9203; Rinehart, et al., Journal of Natural Products, 1990, "Bioactive Compounds from Aquatic and Terrestrial Sources", vol. 53, pp. 771-792; Rinehart et al., Pure and Appl. Chem., 1990, "Biologically active natural products", vol 62, pp. 1277-1280; Rinehart, et al., J. Org. Chem., 1990, "Ecteinascidins 729, 743, 745, 759A, 759B, and 770: Potent Antitumour Agents from the Caribbean Tunicate *Ecteinascidia turbinata*", vol. 55, pp. 4512-4515; Wright et al., J. Org. Chem., 1990, "Antitumour Tetrahydroisoquinoline Alkaloids from the Colonial Ascidian *Ecteinascidia turbinata*", vol. 55, pp. 4508-4512; Sakai et al., Proc. Natl. Acad. Sci. USA 1992, "Additional antitumour ecteinascidins from a Caribbean tunicate: Crystal structures and activities *in vivo*", vol. 89, 11456-11460; Science 1994, "Chemical Prospectors Scour the Seas for Promising Drugs", vol. 266, pp. 1324; Koenig, K.E., "Asymmetric Synthesis", ed. Morrison, Academic Press, Inc., Orlando, FL, vol. 5, 1985, p. 71; Barton, et al., J. Chem Soc. Perkin Trans., 1, 1982, "Synthesis and Properties of a Series of Sterically Hindered Guanidine Bases", pp. 2085; Fukuyama et al., J. Am Chem. Soc., 1982, "Stereocontrolled Total Synthesis of (+) – Saframycin B", vol. 104, pp. 4957; Fukuyama et al., J. Am Chem Soc., 1990, "Total Synthesis of (+) – Saframycin A", vol. 112, p. 3712; Saito, et al., J. Org. Chem., 1989, "Synthesis of Saframycins. Preparation of a Key Tricyclic Lactam Intermediate to Saframycin A", vol. 54, 5391; Still, et al., J. Org. Chem., 1978, "Rapid Chromatographic Technique for Preparative Separations with Moderate Resolution", vol. 43, p. 2923; Kofron, W.G.; Baclawski, L.M., J. Org. Chem., 1976, vol. 41, 1879; Guan et al., J. Biomolec. Struc. & Dynam., vol. 10 pp. 793-817 (1993); Shamma et al., "Carbon-

13 NMR Shift Assignments of Amines and Alkaloids”, p. 206 (1979); Lown et al., *Biochemistry*, 21, 419-428 (1982); Zmijewski et al., *Chem. Biol. Interactions*, 52, 361-375 (1985); Ito, *CRC CRIT. Rev. Anal. Chem.*, 17, 65-143 (1986); Rinehart et al., “Topics in Pharmaceutical Sciences 1989” pp. 613-626, D. D. Breimer, D.J. A. Cromwelin, K.K. Midha, Eds., Amsterdam Medical Press B.V., Noordwijk, The Netherlands (1989); Rinehart et al., “Biological Mass Spectrometry,” 233-258 eds. Burlingame et al., Elsevier Amsterdam (1990); Guan et al., *Jour. Biomolec. Struct. & Dynam.*, vol. 10 pp. 793-817 (1993); Nakagawa et al., *J. Amer. Chem. Soc.*, 111: 2721-2722 (1989); Lichter et al., “Food and Drugs from the Sea Proceedings” (1972), Marine Technology Society, Washington, D.C.1973, 117-127; Sakai et al., *J. Amer. Chem. Soc.* 1996, 118, 9017; García-Rocha et al., *Brit. J. Cancer*, 1996, 73: 875-883; and Pommier et al., *Biochemistry*, 1996, 35: 13303-13309; Rinehart, K.L., *Med. Res. Rev.*, 2000, 20, 1-27 and I. Manzanares et al, *Org. Lett.*, 2000, 2(16), 2545-2548.

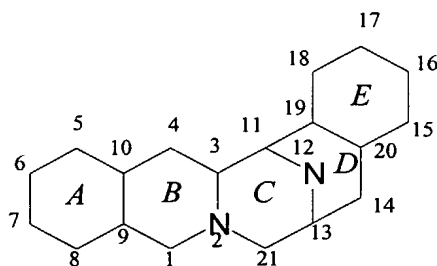
The most promising ecteinascidin is ecteinascidin 743, which is undergoing clinical trials for treatment of cancers. Et 743 has a complex tris(tetrahydroisoquinolinephenol) structure of the following formula (I):



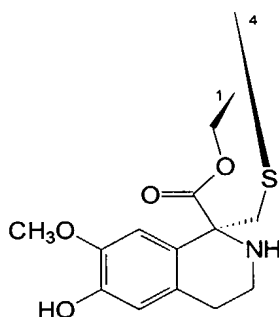
It is currently prepared by isolation from extracts of the marine tunicate *Ecteinascidin turbinata*. The yield is low, and alternative preparative processes have been sought.

## 4

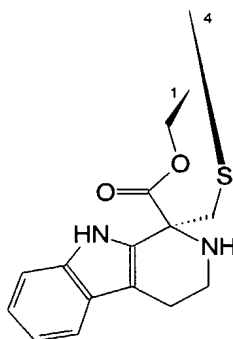
The ecteinascidins include a fused system of five rings (*A*) to (*E*) as shown in the following structure of formula (XIV):



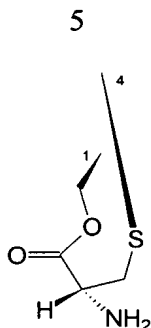
In ecteinascidin 743, the 1,4 bridge has the structure of formula (IV):



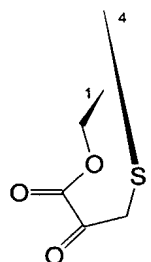
Other known ecteinascidins include compounds with a different bridged cyclic ring system, such as occurs in ecteinascidin 722 and 736, where the bridge has the structure of formula (V):



ecteinascidins 583 and 597, where the bridge has the structure of formula (VI):



and ecteinascidin 594 and 596, where the bridge has the structure of formula (VII):

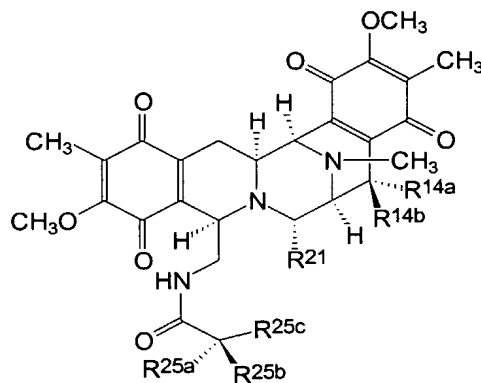


The complete structure for these and related compounds is given in J. Am. Chem. Soc. (1996) 118, 9017-9023.

Further compounds are known with the fused five ring system. In general, they lack the bridged cyclic ring system which is present in the ecteinascidins. They include the bis(tetrahydroisoquinolinequinone) antitumor-antimicrobial antibiotics safracins and saframycins, and the marine natural products renieramicins and xestomycin isolated from cultured microbes or sponges. They all have a common dimeric tetrahydroisoquinoline carbon framework. These compounds can be classified into four types, types I to IV, with respect to the oxidation pattern of the aromatic rings.

Type I, dimeric isoquinolinequinones, is a system of formula (VIII) most commonly occurring in this class of compounds, see the following table I.

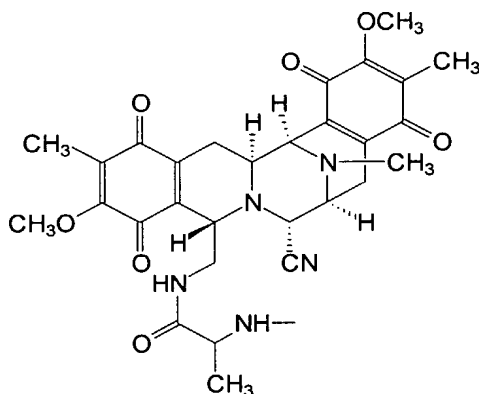
Table I  
Structure of Type I Saframycin Antibiotics



Compound	Substituents					
	R <sup>14a</sup>	R <sup>14b</sup>	R <sup>21</sup>	R <sup>25a</sup>	R <sup>25b</sup>	R <sup>25c</sup>
saframycin A	H	H	CN	O	O	CH <sub>3</sub>
saframycin B	H	H	H	O	O	CH <sub>3</sub>
saframycin C	H	OCH <sub>3</sub>	H	O	O	CH <sub>3</sub>
saframycin G	H	OH	CN	O	O	CH <sub>3</sub>
saframycin H	H	H	CN	OH	CH <sub>2</sub> COCH <sub>3</sub>	CH <sub>3</sub>
saframycin S	H	H	OH	O	O	CH <sub>3</sub>
saframycin Y <sub>3</sub>	H	H	CN	NH <sub>2</sub>	H	CH <sub>3</sub>
saframycin Yd <sub>1</sub>	H	H	CN	NH <sub>2</sub>	H	C <sub>2</sub> H <sub>5</sub>
saframycin Ad <sub>1</sub>	H	H	CN	O	O	C <sub>2</sub> H <sub>5</sub>
saframycin Yd <sub>2</sub>	H	H	CN	NH <sub>2</sub>	H	H
saframycin Y <sub>2b</sub>	H	Q <sup>b</sup>	CN	NH <sub>2</sub>	H	CH <sub>3</sub>
saframycin Y <sub>2b-d</sub>	H	Q <sup>b</sup>	CN	NH <sub>2</sub>	H	C <sub>2</sub> H <sub>5</sub>
saframycin AH <sub>2</sub>	H	H	CN	H <sup>a</sup>	OH <sup>a</sup>	CH <sub>3</sub>
saframycin AH <sub>2</sub> Ac	H	H	CN	H	OAc	CH <sub>3</sub>
saframycin AH <sub>1</sub>	H	H	CN	OH <sup>a</sup>	H <sup>a</sup>	CH <sub>3</sub>
saframycin AH <sub>1</sub> Ac	H	H	CN	OAc	H	CH <sub>3</sub>
saframycin AR <sub>3</sub>	H	H	H	H	OH	CH <sub>3</sub>

<sup>a</sup> assignments are interchangeable.

<sup>b</sup> where the group Q is of formula (IX):

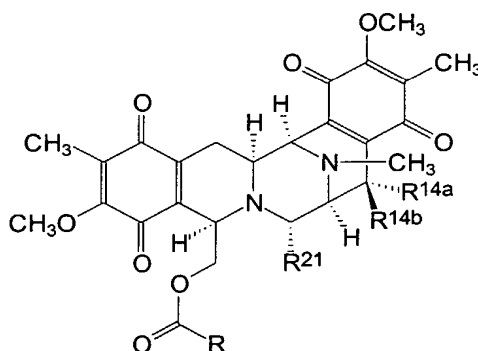


Type I aromatic rings are seen in saframycins A, B and C; G and H; and S isolated from *Streptomyces lavendulae* as minor components. A cyano derivative of saframycin A, called cyanoquinonamine, is known from Japanese Kokai JP-A2 59/225189 and 60/084288. Saframycins Y<sub>3</sub>, Yd<sub>1</sub>, Ad<sub>1</sub> and Yd<sub>2</sub> were produced by *S. lavendulae* by directed biosynthesis, with appropriate supplementation of the culture medium. Saframycins Y<sub>2b</sub> and Y<sub>2b-d</sub> dimers formed by linking the nitrogen on the C-25 of one unit to the C-14 of the other, have also been produced in supplemented culture medium of *S. lavendulae*. Saframycins AR<sub>1</sub> (=AH<sub>2</sub>), a microbial reduction product of saframycin A at C-25 produced by *Rhodococcus amidophilus*, is also prepared by nonstereoselective chemical reduction of saframycin A by sodium borohydride as a 1:1 mixture of epimers followed by chromatographic separation (the other isomer AH<sub>1</sub> is less polar). The further reduction product saframycin AR<sub>3</sub>, 21-decyano-25-dihydro-saframycin A, (= 25-dihydrosaframycin B) was produced by the same microbial conversion. Another type of microbial conversion of saframycin A using a *Nocardia* species produced saframycin B and further reduction by a *Mycobacterium* species produced saframycin AH<sup>1</sup>Ac. The 25-O-acetates of saframycin AH<sub>2</sub> and AH<sub>1</sub> have also been prepared chemically for biological studies.

Type I compounds of formula (X) have also been isolated from marines sponges, see Table II.



Table II  
Structures of Type I Compounds from Marine Sponges



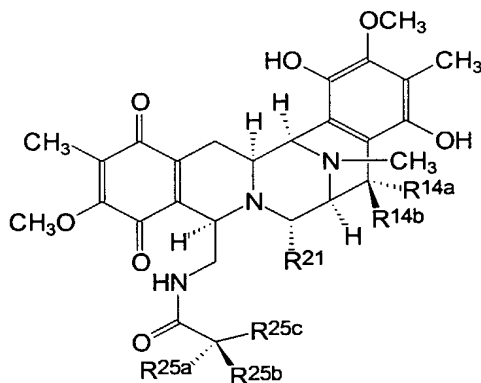
	Substituents			
	R <sup>14a</sup>	R <sup>14b</sup>	R <sup>21</sup>	R
renieramycin A	OH	H	H	-C(CH <sub>3</sub> )=CH-CH <sub>3</sub>
renieramycin B	OC <sub>2</sub> H <sub>5</sub>	H	H	-C(CH <sub>3</sub> )=CH-CH <sub>3</sub>
renieramycin C	OH	O	O	-C(CH <sub>3</sub> )=CH-CH <sub>3</sub>
renieramycin D	OC <sub>2</sub> H <sub>5</sub>	O	O	-C(CH <sub>3</sub> )=CH-CH <sub>3</sub>
renieramycin E	H	H	OH	-C(CH <sub>3</sub> )=CH-CH <sub>3</sub>
renieramycin F	OCH <sub>3</sub>	H	OH	-C(CH <sub>3</sub> )=CH-CH <sub>3</sub>
xestomycin	OCH <sub>3</sub>	H	H	-CH <sub>3</sub>

Renieramycins A-D were isolated from the antimicrobial extract of a sponge, a *Reniera* species collected in Mexico, along with the biogenetically related monomeric isoquinolines renierone and related compounds. The structure of renieramycin A was initially assigned with inverted stereochemistry at C-3, C-11, and C-13. However, careful examination of the <sup>1</sup>H NMR data for new, related compounds renieramycins E and F, isolated from the same sponge collected in Palau, revealed that the ring junction of renieramycins was identical to that of saframycins. This result led to the conclusion that the formerly assigned stereochemistry of renieramycins A to D must be the same as that of saframycins.

Xestomycin was found in a sponge, a *Xestospongia* species collected from Sri Lankan waters.

Type II compounds of formula (XI) with a reduced hydroquinone ring include saframycins D and F, isolated from *S. lavendulae*, and saframycins Mx-1 and Mx-2, isolated from *Myxococcus xanthus*. See table III.

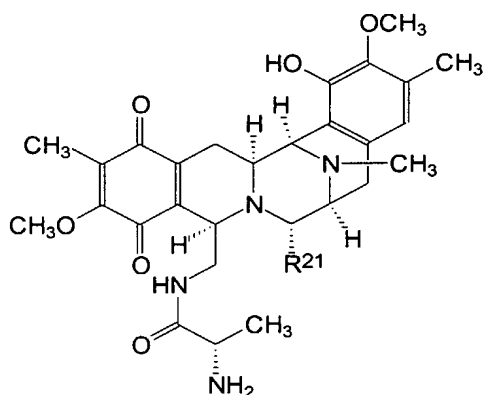
Table III  
Type II Compounds



Compound	Substituents					
	R <sup>14a</sup>	R <sup>14b</sup>	R <sup>21</sup>	R <sup>25a</sup>	R <sup>25b</sup>	R <sup>25c</sup>
saframycin D	O	O	H	O	O	CH <sub>3</sub>
saframycin F	O	O	CN	O	O	CH <sub>3</sub>
saframycin Mx-1	H	OCH <sub>3</sub>	OH	H	CH <sub>3</sub>	NH <sub>2</sub>
saframycin Mx-2	H	OCH <sub>3</sub>	H	H	CH <sub>3</sub>	NH <sub>2</sub>

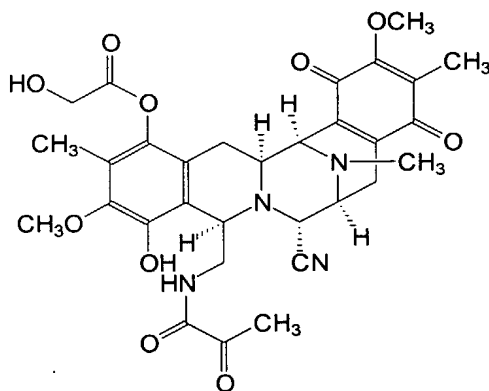
The type III skeleton is found in the antibiotics safracins A and B, isolated from cultured *Pseudomonas fluorescens*. These antibiotics of formula (XII) consist of a tetrahydroisoquinoline-quinone subunit and a tetrahydroisoquinolinephenol subunit.

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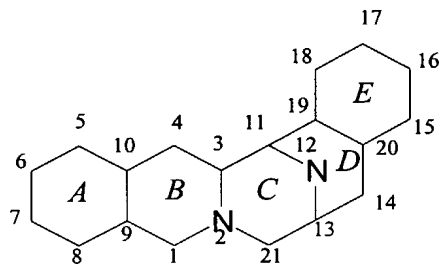
Where  $R^{21}$  is  $-H$  in safracin A and is  $-OH$  in safracin B.

Saframycin R, the only compound classified as the Type IV skeleton, was also isolated from *S. lavendulae*. This compound of formula (XIII), consisting of a hydroquinone ring with a glycolic ester side chain on one of the phenolic oxygens, is conceivably a pro-drug of saframycin A because of its moderate toxicity.



These known compounds include the fused system of five rings of the formula (XIV):

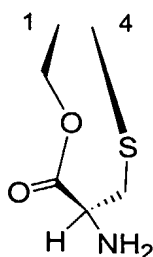
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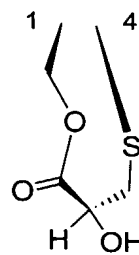
In this text, we refer to this ring structure as the fused ecteinascidin five ring system, though it will be appreciated that the rings *A* and *E* are phenolic in the ecteinascidins and some other compounds, while in other compounds, notably the saframycins, the rings *A* and *E* are quinolic. In the compounds, the rings *B* and *D* are tetrahydro, while ring *C* is perhydro.

#### SUMMARY OF THE INVENTION

The present invention provides compounds having the fused ecteinascidin five ring system and related to ecteinascidins 583 and 597. In ecteinascidins 583 and 597 the 1,4 bridge has the structure of formula (VIa):



VIa



VIb

Certain compounds of this invention have the fused five ring system of ecteinascidins and the bridge structure of formula (VIa), with the  $\text{-NH}_2$  optionally derivatised. These compounds can be acylated on the  $\text{-CHNH}_2\text{-}$  group present in the formula (VI). Other derivative compounds of this invention comprise those where this  $\text{-CHNH}_2\text{-}$  group is replaced by a group  $\text{-CHNHX}_1$  or  $\text{-C(X}_2)_2\text{-}$  where  $\text{X}_1$  or  $\text{X}_2$  are as

defined. The remaining substituents on the fused ecteinascidin five ring system can be the same as those on natural compounds, particularly natural ecteinascidins, or different.

Other compounds of this invention have the fused five ring system of ecteinascidins and the bridge structure of formula (VIb) in which the  $\text{-NH}_2$  group on the bridge has been replaced with an  $\text{-OH}$  group which may be optionally derivatised. These compounds can be acylated on the  $\text{-CHOH-}$  group present in the formula (VIb). Other derivative compounds of this invention comprise those where this  $\text{-CHOH-}$  group is replaced by a group  $\text{-CHOX}_1$  or  $\text{-C(X}_2)_2\text{-}$  where  $\text{X}_1$  or  $\text{X}_2$  are as defined. The remaining substituents on the fused ecteinascidin five ring system can be the same as those on natural compounds, particularly natural ecteinascidins, or different.

In the compounds of this invention, the stereochemistry of the bridgehead carbon atom bearing the  $\text{-OH}$  or  $\text{-NH}_2$  group (or substituted derivatives thereof) can be the same as that of the natural compounds, particularly natural ecteinascidins, or different.

In the compounds of this invention, the fused system of five rings (*A*) to (*E*) of formula (XIV) can be as in the ecteinascidins, or may be as in other related compounds. Thus the rings *A* and *E* can be phenolic or quinolic; the rings *B* and *D* are tetrahydro, and ring *C* is perhydro.

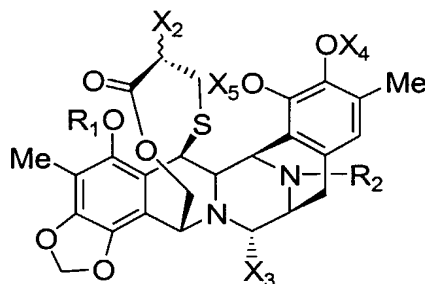
Compounds of this invention exhibit antitumor activity, and the invention provides pharmaceutical compositions of the compounds, along with methods for preparing the compositions and methods of treatment using the compounds or compositions.

The invention also provides new hemisynthetic and synthetic routes to the compounds of this invention.

## PREFERRED EMBODIMENTS

The fused system of five rings (*A*) to (*E*) of formula (XIV) is preferably as in the ecteinascidins, and preferably substituted in positions other than 1,4 with naturally occurring substituents.

In one aspect, the present invention provides new compounds of the formula:



wherein:

the substituent groups defined by  $R_1$ ,  $R_2$  are each independently selected of H,  $C(=O)R'$ , substituted or unsubstituted  $C_1$ - $C_{18}$  alkyl, substituted or unsubstituted  $C_2$ - $C_{18}$  alkenyl, substituted or unsubstituted  $C_2$ - $C_{18}$  alkynyl, substituted or unsubstituted aryl; each of the  $R'$  groups is independently selected from the group consisting of H, OH,  $NO_2$ ,  $NH_2$ , SH, CN, halogen,  $=O$ ,  $C(=O)H$ ,  $C(=O)CH_3$ ,  $CO_2H$ , substituted or unsubstituted  $C_1$ - $C_{18}$  alkyl, substituted or unsubstituted  $C_2$ - $C_{18}$  alkenyl, substituted or unsubstituted  $C_2$ - $C_{18}$  alkynyl, substituted or unsubstituted aryl;

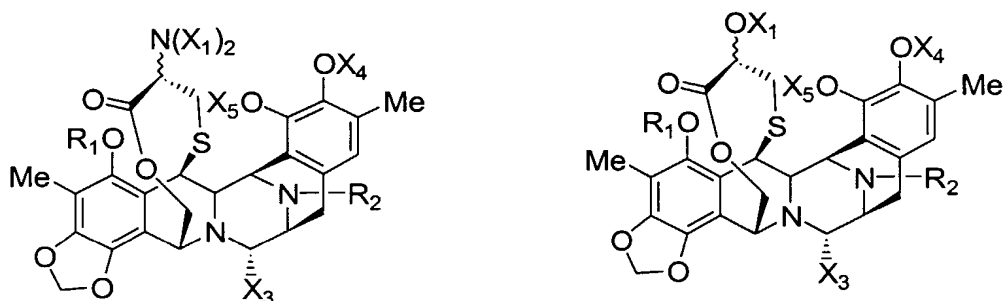
$X_2$  is  $OX_1$  or  $N(X_1)_2$  wherein the or each  $X_1$  is H,  $C(=O)R'$ , substituted or unsubstituted  $C_1$ - $C_{18}$  alkyl, substituted or unsubstituted  $C_2$ - $C_{18}$  alkenyl, substituted or unsubstituted  $C_2$ - $C_{18}$  alkynyl, substituted or unsubstituted aryl, or two  $X_1$  groups may together form a cyclic substituent on the nitrogen atom;

$X_3$  is selected of  $OR_1$ , CN,  $(=O)$ , or H;

$X_4$  is  $-H$  or  $C_1$ - $C_{18}$  alkyl; and

$X_5$  is selected of H, OH, or  $-OR_1$  (wherein  $OR_1$  is as defined above).

In a related aspect, the invention provides compounds of formula:



wherein the substituent groups defined by  $R_1$ ,  $R_2$ ,  $X_3$ ,  $X_4$  and  $X_5$  are as defined; and  $X_1$  is independently selected of H,  $C(=O)R'$ , substituted or unsubstituted  $C_1$ - $C_{18}$  alkyl, substituted or unsubstituted  $C_2$ - $C_{18}$  alkenyl, substituted or unsubstituted  $C_2$ - $C_{18}$  alkynyl, substituted or unsubstituted aryl, or two  $X_1$  groups may together form a cyclic substituent on the nitrogen atom.

Alkyl groups preferably have from 1 to about 12 carbon atoms, more preferably 1 to about 8 carbon atoms, still more preferably 1 to about 6 carbon atoms, and most preferably 1, 2, 3 or 4 carbon atoms. Methyl, ethyl and propyl including isopropyl are particularly preferred alkyl groups in the compounds of the present invention. As used herein, the term alkyl, unless otherwise modified, refers to both cyclic and noncyclic groups, although cyclic groups will comprise at least three carbon ring members. The alkyl groups may be straight chain or branched chain.

Preferred alkenyl and alkynyl groups in the compounds of the present invention have one or more unsaturated linkages and from 2 to about 12 carbon atoms, more preferably 2 to about 8 carbon atoms, still more preferably 2 to about 6 carbon atoms, even more preferably 1, 2, 3 or 4 carbon atoms. The terms alkenyl and alkynyl as used herein refer to both cyclic and noncyclic groups, although straight or branched noncyclic groups are generally more preferred.

Preferred alkoxy groups in the compounds of the present invention include groups having one or more oxygen linkages and from 1 to about 12 carbon atoms, more preferably from

1 to about 8 carbon atoms, and still more preferably 1 to about 6 carbon atoms, and most preferably 1, 2, 3 or 4 carbon atoms.

Preferred alkylthio groups in the compounds of the present invention have one or more thioether linkages and from 1 to about 12 carbon atoms, more preferably from 1 to about 8 carbon atoms, and still more preferably 1 to about 6 carbon atoms. Alkylthio groups having 1, 2, 3 or 4 carbon atoms are particularly preferred.

Preferred alkylsulfinyl groups in the compounds of the present invention include those groups having one or more sulfoxide (SO) groups and from 1 to about 12 carbon atoms, more preferably from 1 to about 8 carbon atoms, and still more preferably 1 to about 6 carbon atoms. Alkylsulfinyl groups having 1, 2, 3 or 4 carbon atoms are particularly preferred.

Preferred alkylsulfonyl groups in the compounds of the present invention include those groups having one or more sulfonyl (SO<sub>2</sub>) groups and from 1 to about 12 carbon atoms, more preferably from 1 to about 8 carbon atoms, and still more preferably 1 to about 6 carbon atoms. Alkylsulfonyl groups having 1, 2, 3 or 4 carbon atoms are particularly preferred.

Preferred aminoalkyl groups include those groups having one or more primary, secondary and/or tertiary amine groups, and from 1 to about 12 carbon atoms, more preferably 1 to about 8 carbon atoms, still more preferably 1 to about 6 carbon atoms, even more preferably 1, 2, 3 or 4 carbon atoms. Secondary and tertiary amine groups are generally more preferred than primary amine moieties.

Suitable heteroaromatic groups in the compounds of the present invention contain one, two or three heteroatoms selected from N, O or S atoms and include, e.g., coumarinyl including 8-coumarinyl, quinolinyl including 8-quinolinyl, pyridyl, pyrazinyl, pyrimidyl, furyl, pyrrolyl, thienyl, thiazolyl, oxazolyl, imidazolyl, indolyl, benzofuranyl and benzothiazolyl. Suitable heteroalicyclic groups in the compounds of the present invention



contain one, two or three heteroatoms selected from N, O or S atoms and include, e.g., tetrahydrofuranyl, tetrahydropyranyl, piperidinyl, morpholino and pyrrolidinyl groups.

Suitable carbocyclic aryl groups in the compounds of the present invention include single and multiple ring compounds, including multiple ring compounds that contain separate and / or fused aryl groups. Typical carbocyclic aryl groups contain 1 to 3 separate or fused rings and from 6 to about 18 carbon ring atoms. Specifically preferred carbocyclic aryl groups include phenyl including substituted phenyl such as 2-substituted phenyl, 3-substituted phenyl, 2, 3-substituted phenyl, 2,5-substituted phenyl, 2,3,5-substituted and 2,4,5-substituted phenyl, including where one or more of the phenyl substituents is an electron-withdrawing group such as halogen, cyano, nitro, alkanoyl, sulfinyl, sulfonyl and the like; naphthyl including 1-naphthyl and 2-naphthyl; biphenyl; phenanthryl; and anthracyl.

Substituent groups defined by R<sub>1</sub>, R<sub>2</sub>, X<sub>1</sub>, X<sub>4</sub> and X<sub>5</sub> are each independently selected from the group consisting of H, OH, OR', SH, SR', SOR', SO<sub>2</sub>R', NO<sub>2</sub>, NH<sub>2</sub>, NHR', N(R')<sub>2</sub>, NHC(O)R', CN, halogen, =O, substituted or unsubstituted C<sub>1</sub>-C<sub>18</sub> alkyl, substituted or unsubstituted C<sub>2</sub>-C<sub>18</sub> alkenyl, substituted or unsubstituted C<sub>2</sub>-C<sub>18</sub> alkynyl, substituted or unsubstituted aryl, substituted or unsubstituted heteroaromatic.

References herein to substituted R' groups in the compounds of the present invention refer to the specified moiety that may be substituted at one or more available positions by one or more suitable groups, e.g., halogen such as fluoro, chloro, bromo and iodo; cyano; hydroxyl; nitro; azido; alkanoyl such as a fluoro, chloro, bromo and iodo: cyano; hydroxyl; nitro; azido; alkanoyl such as a C1-6 alkanoyl group such as acyl and the like; carboxamido; alkyl groups including those groups having 1 to about 12 carbon atoms or from 1 to about 6 carbon atoms and more preferably 1-3 carbon atoms; alkenyl and alkynyl groups including groups having one or more unsaturated linkages and from 2 to about 12 carbon or from 2 to about 6 carbon atoms; alkoxy groups having one or more oxygen linkages and from 1 to about 12 carbon atoms or 1 to about 6 carbon atoms; aryloxy such as phenoxy; alkylthio groups including those moieties having one or more

thioether linkages and from 1 to about 12 carbon atoms or from 1 to about 6 carbon atoms; alkylsulfinyl groups including those moieties having one or more sulfinyl linkages and from 1 to about 12 carbon atoms or from 1 to about 6 carbon atoms; alkylsulfonyl groups including those moieties having one or more sulfonyl linkages and from 1 to about 12 carbon atoms or from 1 to about 6 carbon atoms; aminoalkyl groups such as groups having one or more N atoms and from 1 to about 12 carbon atoms or from 1 to about 6 carbon atoms; carbocyclic aryl having 6 or more carbons, particularly phenyl (e.g., R being a substituted or unsubstituted biphenyl moiety); and aralkyl such as benzyl.

R<sub>1</sub> is preferably C(=O)R', where R' is suitably H or substituted or unsubstituted alkyl, more preferably acetyl.

R<sub>2</sub> is preferably H or methyl, more preferably methyl.

Typically one of X<sub>1</sub> or X<sub>2</sub> is often hydrogen. X<sub>2</sub>, or where permitted X<sub>1</sub> is preferably H; -NHCOalkyl, particularly where the alkyl has up to 16 carbon atoms, such as 1, 4, 7, 15 carbon atoms and may be halosubstituted optionally perhalosubstituted; -NHalkylCOOH particularly where the alkyl has up to 4 carbon atoms; protected -NHCOCH(NH<sub>2</sub>)CH<sub>2</sub>SH where the NH<sub>2</sub> and/or the SH are protected; -NHbiotin; -NHaryl; -NH(aa)<sub>y</sub> where aa is an amino acid acyl and y is suitably 1, 2 or 3 and wherein any NH<sub>2</sub> is optionally derivatised or protected, as with an amide terminal group or a Boc group; phthalimido formed -NX<sub>2</sub>-; alkyl preferably having 1 to 4 carbon atoms; arylalkenyl, especially cinnamoyl which may be substituted as with 3-trifluoromethyl;

Preferred examples of the group X<sub>2</sub> include NHAc, NHCO(CH<sub>2</sub>)<sub>2</sub>COOH, NHCOCH(NHAlloc)CH<sub>2</sub>SFm, NHCO(CH<sub>2</sub>)<sub>14</sub>CH<sub>3</sub>, NHTFA, NHCO(CH<sub>2</sub>)<sub>2</sub>CH<sub>3</sub>, NHCOCH<sub>2</sub>CH(CH<sub>3</sub>)<sub>2</sub>, NHCO(CH<sub>2</sub>)<sub>6</sub>CH<sub>3</sub>, NHBiotin, NHBz, NHCOCinn, NHCO-(*p*-F<sub>3</sub>C)-Cinn, NHCVal-NH<sub>2</sub>, NHCVal-*N*-Ac, NHCVal-*N*-COCinn, NHCVal-Ala-NH<sub>2</sub>, NHCVal-Ala-*N*-Ac, NHCOAla-NH<sub>2</sub>, OH, OAc, NHAc, NHCO(CH<sub>2</sub>)<sub>2</sub>COOH, NHCOCH(NHAlloc)CH<sub>2</sub>SFm, NHCOCH(NH<sub>2</sub>)CH<sub>2</sub>SFm, NPht, NH-(*m*-CO<sub>2</sub>Me)-Bz, NHCO(CH<sub>2</sub>)<sub>14</sub>CH<sub>3</sub>, NMe<sub>2</sub>, NHTFA, NHCO(CH<sub>2</sub>)<sub>2</sub>CH<sub>3</sub>, NHCOCH<sub>2</sub>CH(CH<sub>3</sub>)<sub>2</sub>,

NHCO(CH<sub>2</sub>)<sub>6</sub>CH<sub>3</sub>, NHAlloc, NHTroc, NHBiotin, NHBz, NHCOCinn, NHCO-(*p*-F<sub>3</sub>C)-Cinn, NHCOVal-NH<sub>2</sub>, NHCOVal-*N*-Ac, NHCOVal-*N*-COCinn, NHCOVal-Ala-NH<sub>2</sub>, NHCOVal-Ala-*N*-Ac, NHCOVal-Ala-*N*-COCinn, NHCOAla-NH<sub>2</sub>, NHCOAla-*N*-Ac, NHCOAla-*N*-COCinn, OH, OAc, NHAc, NHCO(CH<sub>2</sub>)<sub>2</sub>COOH, NHCOCH(NHAlloc)CH<sub>2</sub>SFm, Npht, along with similar groups where the number of carbon atoms is varied or the amino acid is changed or another change of this kind is made to give a similar group.

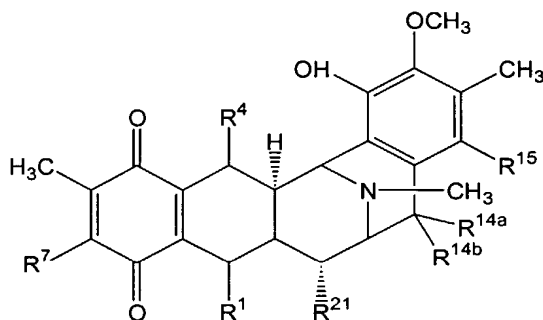
Other preferred examples of the group X<sub>2</sub> include OH, OAc, OCOCF<sub>3</sub>, OCOCH<sub>2</sub>CH<sub>2</sub>CH<sub>3</sub>, OCO(CH<sub>2</sub>)<sub>6</sub>CH<sub>3</sub>, OCO(CH<sub>2</sub>)<sub>14</sub>CH<sub>3</sub>, OCOCH=CHPh, OSO<sub>2</sub>CH<sub>3</sub> along with similar groups where the number of carbon atoms is varied or different substituent groups are introduced or another change of this kind is made to give a similar group.

X<sub>3</sub> is preferably OH or CN.

X<sub>4</sub> is H or Me, preferably Me.

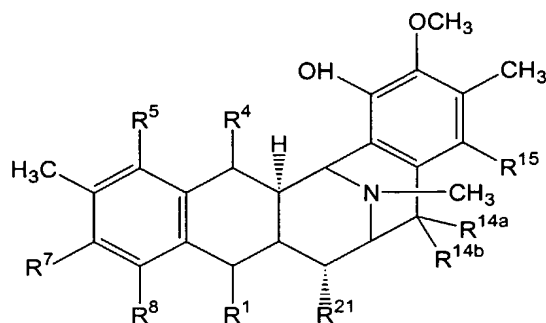
X<sub>5</sub> is H or C<sub>1-18</sub> alkyl, preferably H.

In a further, more general aspect of this invention, the compounds are typically of the formula (XVIIa):



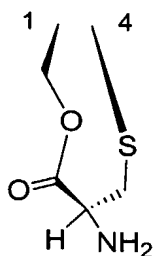
or formula (XVIIb):

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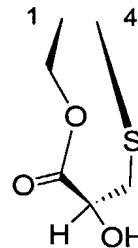


where

$R^1$  and  $R^4$  together form a group of formula (VIa) or (VIb):



VIa



VIb

$R^5$  is -H or -OH;

$R^7$  is -OCH<sub>3</sub> and  $R^8$  is -OH or  $R^7$  and  $R^8$  together form a group -O-CH<sub>2</sub>-O-;

$R^{14a}$  and  $R^{14b}$  are both -H or one is -H and the other is -OH, -OCH<sub>3</sub> or -OCH<sub>2</sub>CH<sub>3</sub>, or  $R^{14a}$  and  $R^{14b}$  together form a keto group; and

$R^{15}$  is -H or -OH;

$R^{21}$  is -H, -OH or -CN;

and derivatives including acyl derivatives thereof especially where  $R^5$  is acetyloxy or other acyloxy group of up to 4 carbon atoms, and including derivatives where the group -NCH<sub>3</sub>- at the 12-position is replaced by -NH- or -NCH<sub>2</sub>CH<sub>3</sub>-, and derivatives where the -NH<sub>2</sub> group in the compound of formula (VIa) and the -OH group in the compound of formula (VIb) are optionally derivatised.

The group  $R_1$  with  $R_4$  can be acylated on the -CHNH<sub>2</sub> - or -CHOH - group present in the formulae (VIa and VIb). Other derivative compounds of this invention comprise those where the -CHNH<sub>2</sub> group of VIa is replaced by a group -CHNHX<sub>1</sub> or -

$C(X_2)_2$ - or where the  $-CHOH$  group of VIb is replaced by  $CHOX_1$  or  $-C(X_2)_2$ - where  $X_1$  or  $X_2$  are as defined.

Preferred compounds are of the formula (XVIIb).

Furthermore, in preferred compounds of this invention,  $R^7$  and  $R^8$  together form a group  $-O-CH_2-O-$ .

The acyl derivatives can be N-acyl or N-thioacyl derivatives thereof, as well as cyclic amides. The acyl groups can illustratively be alkanoyl, haloalkanoyl, arylalkanoyl, alkenyl, heterocyclacyl, aroyl, arylaroyl, haloaroyl, nitroaroyl, or other acyl groups. The acyl groups can be of formula  $-CO-R^a$ , where  $R^a$  can be various groups such as alkyl, alkoxy, alkylene, arylalkyl, arylalkylene, amino acid acyl, or heterocyclyl, each optionally substituted with halo, cyano, nitro, carboxyalkyl, alkoxy, aryl, aryloxy, heterocyclyl, heterocycloxy, alkyl, amino or substituted amino. Other acylating agents include isothiocyanates, such as aryl isothiocyanates, notably phenyl isocyanate. The alkyl, alkoxy or alkylene groups of  $R^a$  suitably have 1 to 6 or 12 carbon atoms, and can be linear, branched or cyclic. Aryl groups are typically phenyl, biphenyl or naphthyl. Heterocyclyl groups can be aromatic or partially or completely unsaturated and suitably have 4 to 8 ring atoms, more preferably 5 or 6 ring atoms, with one or more heteroatoms selected from nitrogen, sulphur and oxygen.

Without being exhaustive, typical  $R^a$  groups include alkyl, haloalkyl, alkoxyalkyl, haloalkoxyalkyl, arylalkylene, haloalkylarylalkylene, acyl, haloacyl, arylalkyl, alkenyl and amino acid. For example,  $R^a-CO-$  can be acetyl, trifluoroacetyl, 2,2,2-trichloroethoxycarbonyl, isovalerylcabonyl, trans-3-(trifluoromethyl)cinnamoylcabonyl, heptafluorobutyrylcabonyl, decanoylcabonyl, trans-cinnamoylcabonyl, butyrylcabonyl, 3-chloropropionylcabonyl, cinnamoylcabonyl, 4-methylcinnamoylcabonyl, hydrocinnamoylcabonyl, or trans-hexenoylcabonyl, or alanyl, arginyl, aspartyl, asparagyl, cystyl, glutamyl, glutaminyl, glycyl, histidyl, hydroxypropyl., isoleucyl, leucyl, lysyl, methionyl, phenylalanyl, prolyl, seryl, threonyl,

thyronyl, tryptophyl, tyrosyl, valyl, as well as other less common amino acid acyl groups, as well as phthalimido and other cyclic amides. Other examples may be found among the listed protecting groups.

Compounds wherein  $-\text{CO}-\text{R}^a$  is derived from an amino acid and include an amino group can themselves form acyl derivatives. Suitable N-acyl compounds include dipeptides which in turn can form N-acyl derivatives.

Preferably  $\text{R}^{14a}$  and  $\text{R}^{14b}$  are hydrogen. Preferably  $\text{R}^{15}$  is hydrogen. The O-acyl derivatives are suitably aliphatic O-acyl derivatives, especially acyl derivatives of 1 to 4 carbon atoms, and typically an O-acetyl group, notably at the 5-position.

Suitable protecting groups for phenols and hydroxy groups include ethers and esters, such as alkyl, alkoxyalkyl, aryloxyalkyl, alkoxyalkoxyalkyl, alkylsilylalkoxyalkyl, alkylthioalkyl, arylthioalkyl, azidoalkyl, cyanoalkyl, chloroalkyl, heterocyclic, arylacyl, haloarylacyl, cycloalkylalkyl, alkenyl, cycloalkyl, alkylarylalkyl, alkoxyarylalkyl, nitroarylalkyl, haloarylalkyl, alkylaminocarbonylarylalkyl, alkylsulfinylarylalkyl, alkylsilyl and other ethers, and arylacyl, aryl alkyl carbonate, aliphatic carbonate, alkylsulfinylarylalkyl carbonate, alkyl carbonate, aryl haloalkyl carbonate, aryl alkenyl carbonate, aryl carbamate, alkyl phosphinyl, alkylphosphinothioyl, aryl phosphinothioyl, aryl alkyl sulphonate and other esters. Such groups may optionally be substituted with the previously mentioned groups in  $\text{R}^1$ .

Suitable protecting groups for amines include carbamates, amides, and other protecting groups, such as alkyl, arylalkyl, sulfo- or halo- arylalkyl, haloalkyl, alkylsilylalkyl, arylalkyl, cycloalkylalkyl, alkylarylalkyl, heterocyclalkyl, nitroarylalkyl, acylaminoalkyl, nitroaryldithioarylalkyl, dicycloalkylcarboxamidoalkyl, cycloalkyl, alkenyl, arylalkenyl, nitroarylalkenyl, heterocyclalkenyl, heterocycl, hydroxyheterocycl, alkylthio, alkoxy- or halo- or alkylsulfinyl arylalkyl, heterocyclacyl, and other carbamates, and alkanoyl, haloalkanoyl, arylalkanoyl, alkenoyl, heterocyclacyl, aroyl, arylaroyl, haloaroyl, nitroaroyl, and other amides, as

well as alkyl, alkenyl, alkylsilylalkoxyalkyl, alkoxyalkyl, cyanoalkyl, heterocyclyl, alkoxyarylalkyl, cycloalkyl, nitroaryl, arylalkyl, alkoxy- or hydroxy- arylalkyl, and many other groups. Such groups may optionally be substituted with the previously mentioned groups in R<sup>1</sup>.

Examples of such protecting groups are given in the following tables.

protection for -OH group

ethers	abbreviation
methyl	
methoxymethyl	MOM
benzyloxymethyl	BOM
methoxyethoxymethyl	MEM
2-(trimethylsilyl)ethoxymethyl	SEM
methylthiomethyl	MTM
phenylthiomethyl	PTM
azidomethyl	
cyanomethyl	
2,2-dichloro-1,1-difluoroethyl	
2-chloroethyl	
2-bromoethyl	
tetrahydropyranyl	THP
1-ethoxyethyl	EE
phenacyl	
4-bromophenacyl	
cyclopropylmethyl	
allyl	
propargyl	
isopropyl	

cyclohexyl

*t*-butyl

benzyl

2,6-dimethylbenzyl

4-methoxybenzyl

MPM or PMB

*o*-nitrobenzyl

2,6-dichlorobenzyl

3,4-dichlorobenzyl

4-(dimethylamino)carbonylbenzyl

4-methylsulfinylbenzyl

Msib

9-anthrylmethyl

4-picolyl

heptafluoro-*p*-tolyl

tetrafluoro-4-pyridyl

trimethylsilyl

TMS

*t*-butyldimethylsilyl

TBDMS

*t*-butyldiphenylsilyl

TBDPS

triisopropylsilyl

TIPS



## esters

aryl formate

aryl acetate

aryl levulinate

aryl pivaloate

ArOPv

aryl benzoate

aryl 9-fluorocarboxylate

aryl methyl carbonate

1-adamantyl carbonate

*t*-butyl carbonate

BOC-OAr

4-methylsulfinylbenzyl carbonate

MsZ-OAr

2,4-dimethylpent-3-yl carbonate

Doc-OAr

aryl 2,2,2-trichloroethyl carbonate

aryl vinyl carbonate

aryl benzyl carbonate

aryl carbamate

dimethylphosphinyl

Dmp-OAr

dimethylphosphinothioyl

Mpt-OAr

diphenylphosphinothioyl

Dpt-OAr

aryl methanesulfonate

aryl toluenesulfonate

aryl 2-formylbenzenesulfonate

protection for the -NH<sub>2</sub> group

carbarnates	abbreviation
methyl	
ethyl	
9-fluorenylmethyl	Fmoc
9-(2-sulfo)fluorenylmethyl	
9-(2,7-dibromo)fluorenylmethyl	
17-tetrabenzo[ <i>a,c,g,i</i> ]fluorenylmethyl	Tbfmoc
2-chloro-3-indenylmethyl	Climoc
benz[ <i>f</i> ]inden-3-ylmethyl	Bimoc
2,7-di- <i>t</i> -butyl[9-(10,10-dioxo-10,10,10,10-tetrahydrothioxanthyl)]methyl	DBD-Tmoc
2,2,2-trichloroethyl	Troc
2-trimethylsilylethyl	Teoc
2-phenylethyl	hZ
1-(1-adamantyl)-1-methylethyl	Adpoc
2-chlooeethyl	
1,1-dimethyl-2-chloroethyl	
1,1-dimethyl-2-bromoethyl	
1,1-dimethyl-2,2-dibromoethyl	DB- <i>t</i> -BOC
1,1-dimethyl-2,2,2-trichloroethyl	TCBOC
1-methyl-1-(4-biphenyl)ethyl	Bpoc
1-(3,5-di- <i>t</i> -butylphenyl)-1-1-methylethyl	<i>t</i> -Burmeoc
2-(2'-and 4'-pyridyl)ethyl	Pyoc
2,2-bis(4'-nitrophenyl)ethyl	Bnpeoc
<i>n</i> -(2-pivaloylamino)-1,1-dimethylethyl	
2-[(2-nitrophenyl)dithio]-1-phenylethyl	NpSSPeoc

2-( <i>n,n</i> -dicyclohexylcarboxamido)ethyl	
<i>t</i> -butyl	BOC
1-adamantyl	1-Adoc
2-adamantyl	2-Adoc
vinyl	Voc
allyl	Aloc or Alloc
1-isopropylallyl	Ipaoc
cinnamyl	Coc
4-nitrocinnamyl	Noc
3-(3'-pyridyl)prop-2-enyl	Paloc
8-quinolyl	
<i>n</i> -hydroxypiperidiny	
alkyldithio	
benzyl	Cbz or Z
<i>p</i> -methoxybenzyl	Moz
<i>p</i> -nitrobenzyl	PNZ
<i>p</i> -bromobenzyl	
<i>p</i> -chlorobenzyl	
2,4-dichlorobenzyl	
4-methylsulfinylbenzyl	MsZ
9-anthrylmethyl	
diphenylmethyl	
phenothiazinyl-(10)-carbonyl	
<i>n'</i> - <i>p</i> -toluenesulfonylaminocarbonyl	
<i>n'</i> -phenylaminothiocarbonyl	

## amides

formamide

acetamide

chloroacetamide

trifluoroacetamide

TFA

phenylacetamide

3-phenylpropanamide

pent-4-enamide

picolinamide

3-pyridylcarboxamide

benzamide

*p*-phenylbenzamide*n*-phthalimide*n*-tetrachlorophthalimide

TCP

4-nitro-*n*-phthalimide*n*-dithiasuccinimide

Dts

*n*-2,3-diphenylmaleimide*n*-2,5-dimethylpyrrole*n*-2,5-bis(triisopropylsiloxy)pyrrole

BIPSOP

*n*-1,1,4,4-tetramethyldisilazacyclopentane adduct

STABASE

1,1,3,3-tetramethyl-1,3-disilaisoindoline

BSB

## special -NH protective groups

*n*-methylamine*n*-*t*-butylamine*n*-allylamine*n*-[2-trimethylsilyl]ethoxy]methylamine

SEM

<i>n</i> -3-acetoxypropylamine	
<i>n</i> -cyanomethylamine	
<i>n</i> -(1-isopropyl-4-nitro-2-oxo-3-pyrrolin-3-yl)amine	
<i>n</i> -2,4-dimethoxybenzylamine	Dmb
2-azanorbornenes	
<i>n</i> -2,4-dinitrophenylamine	
<i>n</i> -benzylamine	Bn
<i>n</i> -4-methoxybenzylamine	MPM
<i>n</i> -2,4-dimethoxybenzylamine	DMPM
<i>n</i> -2-hydroxybenzylamine	Hbn
<i>n</i> -(diphenylmethyl)amino	DPM
<i>n</i> -bis(4-methoxyphenyl)methylamine	
<i>n</i> -5-dibenzosuberylamine	DBS
<i>n</i> -triphenylmethylamine	Tr
<i>n</i> -[(4-methoxyphenyl)diphenylmethyl]amino	MMTr
<i>n</i> -9-phenylflurenylamine	Pf
<i>n</i> -ferrocenylmethylamine	Fcm
<i>n</i> -2-picolylamine <i>n'</i> -oxide	
<i>n</i> -1,1-dimethylthiomethyleneamine	
<i>n</i> -benzylideneamine	
<i>n</i> - <i>p</i> -methoxybenzylideneamine	
<i>n</i> -diphenylmethylenamine	
<i>n</i> -(5,5-dimethyl-3-oxo-1-cyclohexenyl)amine	
<i>n</i> -nitroamine	
<i>n</i> -nitrosoamine	
diphenylphosphinamide	Dpp
dimethylthiophosphinamide	Mpt
diphenylthiophosphinamide	Ppt
dibenzyl phosphoramidate	
2-nitrobenzenesulfenamide	Nps
<i>n</i> -1-(2,2,2-trifluoro-1,1-diphenyl)ethylsulfenamide	TDE

3-nitro-2-pyridinesulfenamide

Npys

*p*-toluenesulfonamide

Ts

benzenesulfonamide

A preferred class of compounds of this invention include compounds of formula (XVIIb), where one or more, preferably all of the following conditions are met:

the amino group in the group of formula (VIa) is derivatised;

the hydroxy group in the group of formula (VIb) is derivatised;

$R^5$  is  $OR_1$ ;

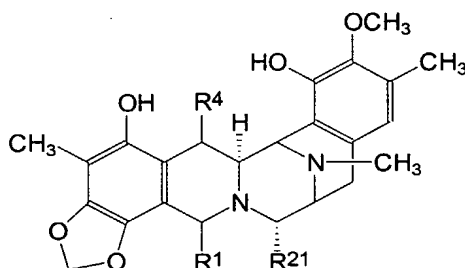
$R^7$  and  $R^8$  together form a group  $-O-CH_2-O-$ ;

$R^{14a}$  and  $R^{14b}$  are both  $-H$ ;

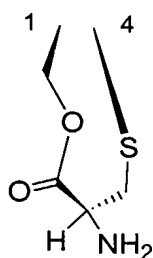
$R^{15}$  is  $H$ ; and/or

$R^{21}$  is  $-OH$  or  $-CN$ .

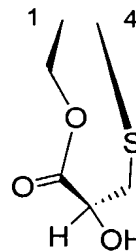
Particular ecteinascidin products of this invention include compounds of the formula (XVIII);



where  $R_1$  and  $R_4$  form a group of formula (VIa or VIb):



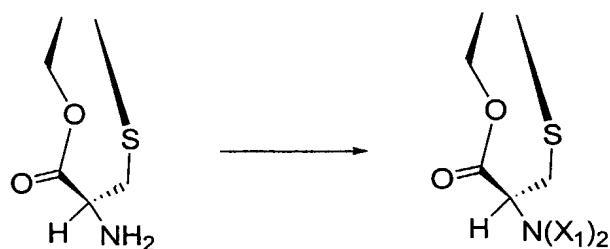
VIa



VIb

$R^{21}$  is-H, -OH or -CN, more particularly -OH or -CN;  
and acyl derivatives thereof, more particularly 5-acyl derivatives including the 5-acetyl derivative, and where the -NH<sub>2</sub> group in the structure of formula (VIa) and the -OH group in the structure of formula (VIb) are optionally derivatised.

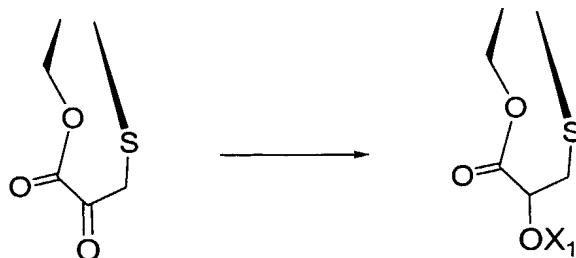
Compounds of the present invention notably with one of two group  $X_1$  can be prepared synthetically from the intermediate compound (47) described in the U.S. Patent No 5,721,362, or a similar compound. Thus the present invention provides a process which involves derivatisation of the 1,4 bridge amino group, according to the following reaction scheme:



where  $X_1$  is as defined, and other substituent groups on the molecule can be protected or derivatised as desired or appropriate.

Compounds of this invention notably with the groups  $X_2$  being -OX<sub>2</sub> can be prepared from the intermediate compound (15) described in the U.S. Patent No 5,721,362

or a similar compound. Thus, the present invention provides a process which involves derivatisation of the 1,4 bridge amino group, according to the following reaction scheme:

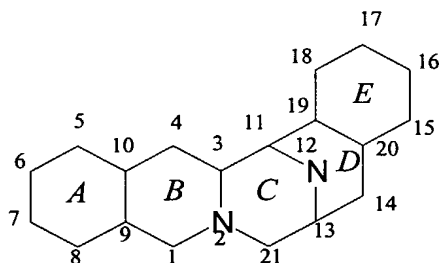


where  $X_1$  is as defined, and other substituent groups on the molecule can be protected or derivatised as desired or appropriate. The reaction may proceed with formation of a substituent  $-OX_1$  where  $X_1$  is hydrogen, and then conversion to a compound where  $X_1$  is another group.

It will be apparent that compounds of this invention may also be prepared by modification of the synthetic steps employed in the U.S. Patent No 5,721,362. Thus, for instance, different reactive groups may be introduced at functional positions, for example at the 5- or 18- positions.

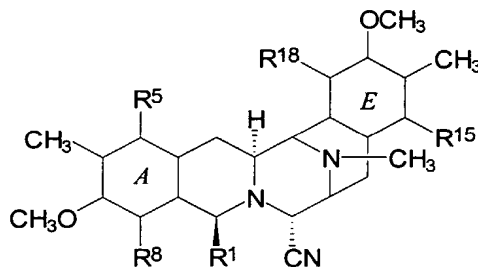
A more general route to compounds of this invention is provided, and was first disclosed in WO 00/69862, incorporated herein in full by reference and from which priority is claimed.

A typical process of that WO application concerns method for preparing a compound with a fused ring structure of formula (XIV):





which comprises one or more reactions starting from a 21-cyano compound of formula (XVI):



where:

R<sup>1</sup> is an amidomethylene group or an acyloxymethylene group;

R<sup>5</sup> and R<sup>8</sup> are independently chosen from -H, -OH or -OCOCH<sub>2</sub>OH, or R<sup>5</sup> and R<sup>8</sup> are both keto and the ring A is a *p*-benzoquinone ring;

R<sup>14a</sup> and R<sup>14b</sup> are both -H or one is -H and the other is -OH, -OCH<sub>3</sub> or -OCH<sub>2</sub>CH<sub>3</sub> or R<sup>14a</sup> and R<sup>14b</sup> together form a keto group; and

R<sup>15</sup> and R<sup>18</sup> are independently chosen from -H or -OH, or R<sup>15</sup> and R<sup>18</sup> are both keto and the ring E is a *p*-benzoquinone ring.

In particular, such a method can provide a route to the starting materials for the reactions of Schemes I and II, along with related compounds.

Antitumoural activities of these compounds include leukaemias, lung cancer, colon cancer, kidney cancer, prostate cancer, ovarian cancer, breast cancer, sarcomas and melanomas.

Another especially preferred embodiment of the present invention is pharmaceutical compositions useful as antitumour agents which contain as active

ingredient a compound or compounds of the invention, as well as the processes for their preparation.

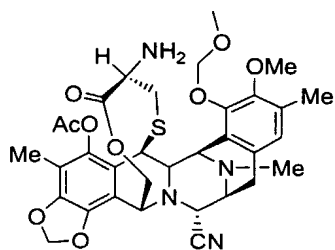
Examples of pharmaceutical compositions include any solid (tablets, pills, capsules, granules etc.) or liquid (solutions, suspensions or emulsions) with suitable composition or oral, topical or parenteral administration.

Administration of the compounds or compositions of the present invention may be any suitable method, such as intravenous infusion, oral preparation, intraperitoneal and intravenous preparation.

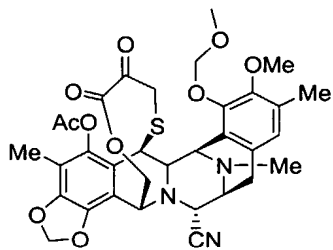
For the avoidance of doubt, the stereochemistries indicated in this patent specification are based on our understanding of the correct stereochemistry of the natural products. To the extent that an error is discovered in the assigned stereochemistry, then the appropriate correction needs to be made in the formulae given throughout in this patent specification. Furthermore, to the extent that the syntheses are capable of modification, this invention extends to stereoisomers.

#### DETAILED DESCRIPTION OF PREFERRED PROCESSES

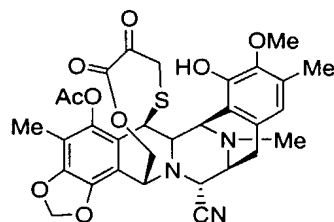
The compounds of the present invention can be synthetically prepared from the intermediate compounds 47 and 15 described in the U.S. Patent No 5,721,362, the compound 36 described in WO 00/69862 and from the secondary products (numbered here as 23 and 24) obtained in some deprotection steps using  $\text{AlCl}_3$  of the compound 33 of WO 00/69862.



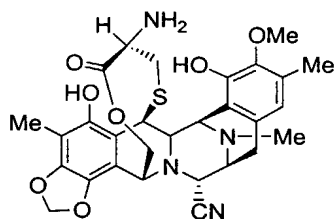
47 (1)



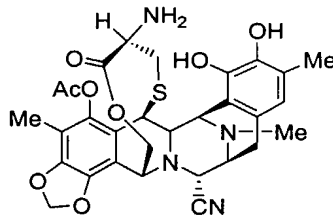
15 (10)



36 (5)



(23)



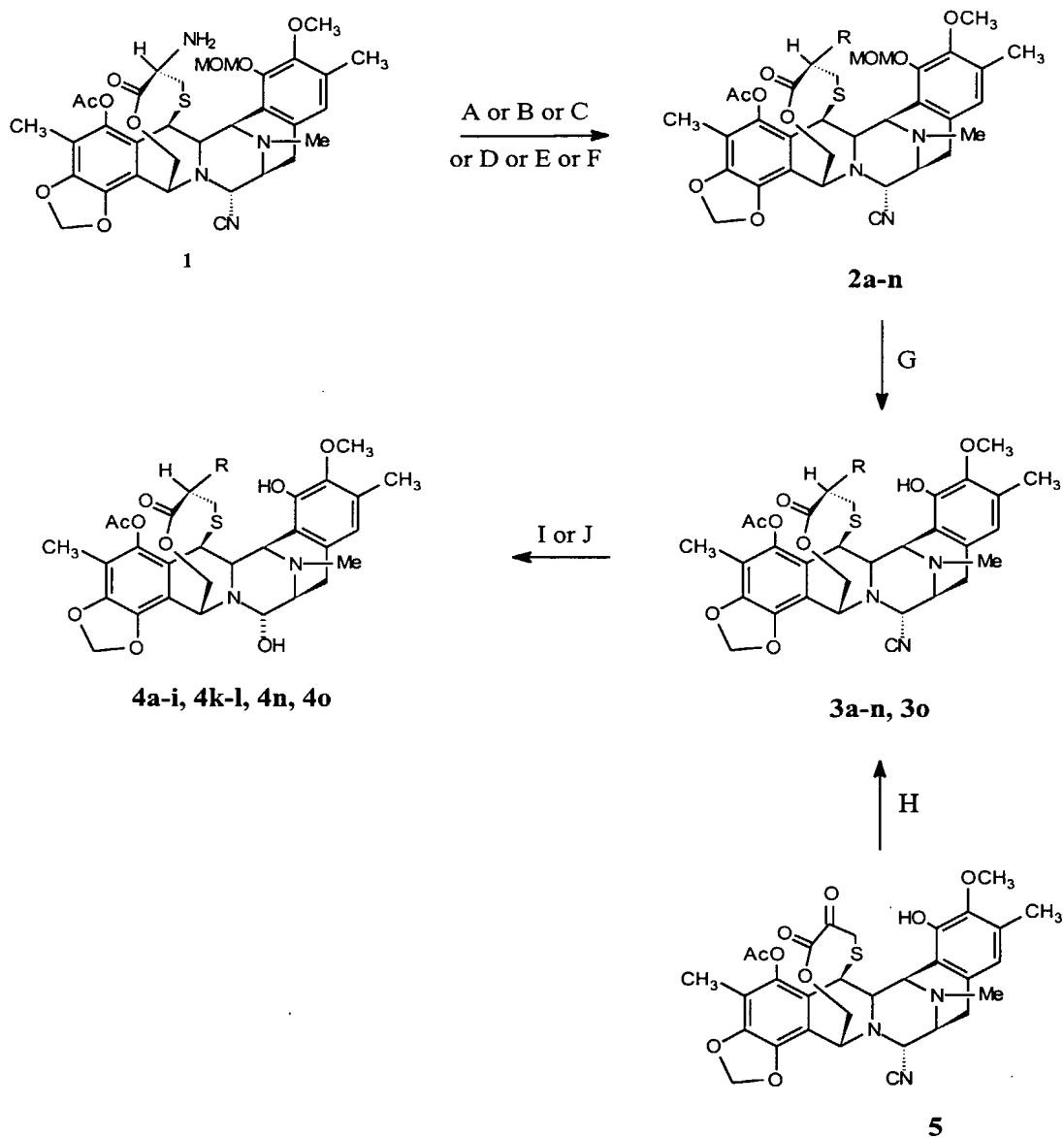
(24)

Compound (1) corresponds to the synthetic intermediate (47) described in the US patent No 5,721,362. Compounds 27 and 28 included in Table IV are described as 35 and 34 in WO 00/69862.

Some of the preferred methods of producing the compound of formula I are described below in the following reaction schemes with examples of typical substituent groups. These typical substituents are not limiting of the invention, and the process is to be understood in the more general sense, without special regard to the identities indicated by the code letters.

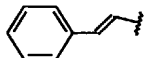
Numerous active antitumoral compounds have been prepared from this compounds and it is believed that many more compounds can be formed in accordance with the teachings of the present disclosure.

## SCHEME I



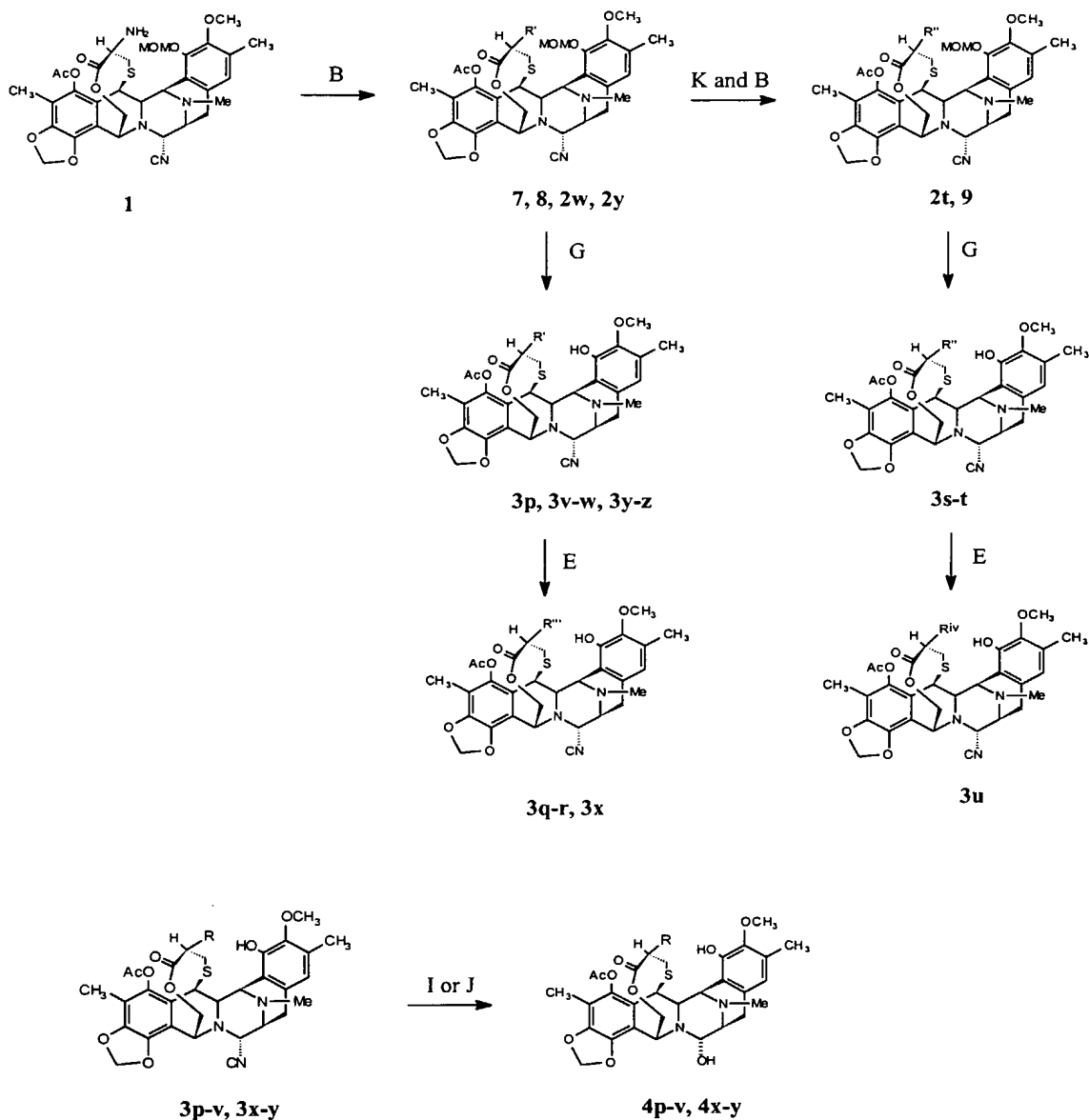
R:  
**a:** AcNH-  
**b:** F<sub>3</sub>CCONH-  
**c:** CH<sub>3</sub>(CH<sub>2</sub>)<sub>2</sub>CONH-  
**d:** (CH<sub>3</sub>)<sub>2</sub>CHCH<sub>2</sub>CONH-  
**e:** CH<sub>3</sub>(CH<sub>2</sub>)<sub>6</sub>CONH-  
**f:** CH<sub>3</sub>(CH<sub>2</sub>)<sub>14</sub>CONH-  
**g:** BzNH-  
**h:** CinnCONH-

Cinn:



**i:** p-F<sub>3</sub>C-CinnCONH-  
**j:** PhN-  
**k:** BiotinCONH-  
**l:** HO<sub>2</sub>CCH<sub>2</sub>CH<sub>2</sub>CONH-  
**m:** (CH<sub>3</sub>)<sub>2</sub>N-  
**n:** BnNH-  
**o:** PrNH-

## SCHEME II

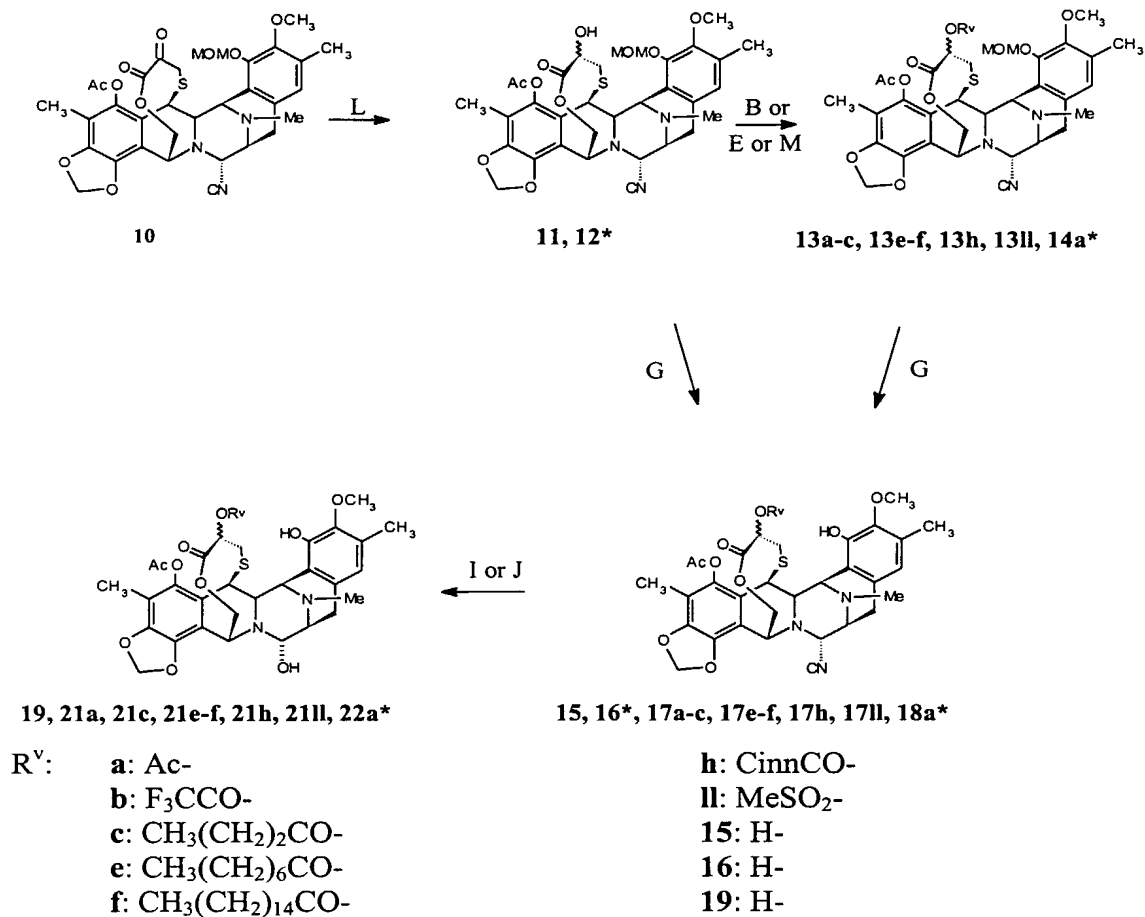


R = R', R'', R''', R<sup>iv</sup>

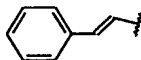
R:  
**p**: NH<sub>2</sub>-ValCONH-  
**q**: Ac-N-ValCONH-  
**r**: CinnCO-N-ValCONH-  
**s**: NH<sub>2</sub>-Ala-ValCONH-  
**t**: Ac-N-Ala-ValCONH-  
**u**: CinnCO-N-Ala-ValCONH-  
**v**: NH<sub>2</sub>-AlaCONH-

**w**: Ac-N-AlaCONH-  
**x**: CinnCO-N-AlaCONH-  
**y**: FmSCH<sub>2</sub>CH(NHAlloc)CONH-  
**z**: FmSCH<sub>2</sub>CH(NH<sub>2</sub>)CONH-  
**7**: Boc-N-ValCONH-  
**8**: Boc-N-AlaCONH-  
**9**: Boc-N-Ala-ValCONH

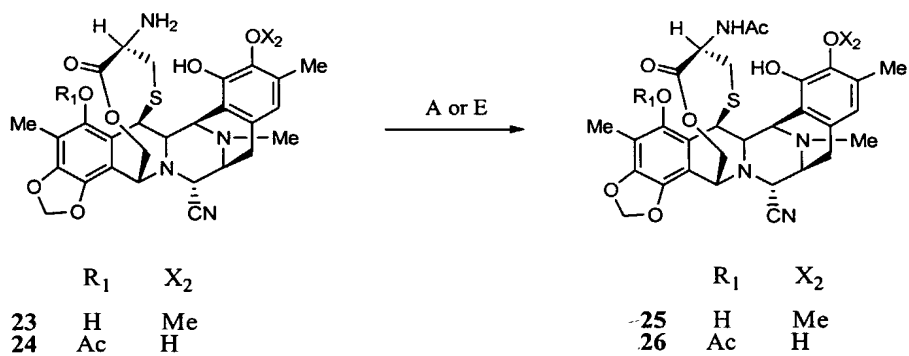
## SCHEME III



Cinn:



## SCHEME IV



The type of reactions are the following:

Methods A, B, C, E and M include different acylation methods with acid chlorides, anhydrides, acids or sulfonyl chlorides, to obtain amide or ester bonds.

Methods D and H involve reductive alkylation reactions between an aldehyde and 1 or an amine and 5 to give 2m or 3o.

Method F transforms compound 1 to 2n by reaction with BnBr and Cs<sub>2</sub>CO<sub>3</sub>.

Method G involves the deprotection of methoxymethyl group (MOM) or MOM/tert-butyloxy carbonyl groups or MOM/allyloxy carbonyl groups using trimethylchlorosilane (TMSCl) and sodium iodide.

Methods I (AgNO<sub>3</sub>) and J (CuBr) convert CN into OH in position C-21.

Method K involves the hydrolysis of a carbamate bond using aqueous trifluoroacetic acid.

Method L converts a carbonyl group to an alcohol by reduction with NaCNBH<sub>3</sub> in the presence of acetic acid. With this reaction a new chiral center is generated. Taking into account steric effects and spectroscopic data, it seems that the main compound (11) has R configuration at this center and the secondary product (12\*) has S configuration. On this basis 13, 15, 17, 19, 21 will have R configuration and 14\*, 18\* and 22\* will have S configuration. These assignments have been made based on the available spectral data and as such, in the absence of specific studies to confirm the assignments, should be considered as only tentative.

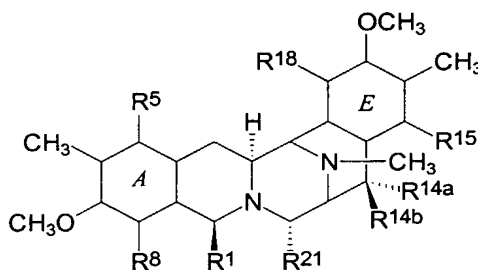
Modified processes can be used to prepare other compounds of this invention. In particular the starting material and/or reagents and reactions can be varied to suit other combinations of the substituent groups.

In another aspect, the present invention is directed at the use of a known compound, safracin B, also referred to as quinonamine, in hemisynthetic synthesis.

More generally, the invention relates to a hemisynthetic process for the formation of intermediates, derivatives and related structures of ecteinascidin or other tetrahydroisoquinolinephenol compounds starting from natural bis(tetrahydroisoquinoline) alkaloids.

Suitable preferred starting materials for the hemi-synthetic process include the classes of saframycin and safracin antibiotics available from different culture broths, and also the classes of reineramicin and xestomycin compounds available from marine sponges.

A general formula (XV) for the starting compounds is as follows:



where:

$R^1$  is an amidomethylene group such as  $-\text{CH}_2\text{-NH-CO-CR}^{25a}\text{R}^{25b}\text{R}^{25c}$  where  $R^{25a}$  and  $R^{25b}$  form a keto group or one is  $-\text{OH}$ ,  $-\text{NH}_2$  or  $-\text{OCOCH}_3$  and the other is  $-\text{CH}_2\text{COCH}_3$ ,  $-\text{H}$ ,  $-\text{OH}$  or  $-\text{OCOCH}_3$ , provided that when  $R^{25a}$  is  $-\text{OH}$  or  $-\text{NH}_2$  then  $R^{25b}$  is not  $-\text{OH}$ , and  $R^{25c}$  is  $-\text{H}$ ,  $-\text{CH}_3$  or  $-\text{CH}_2\text{CH}_3$ , or  $R^1$  is an acyloxymethylene group such as  $-\text{CH}_2\text{-O-CO-R}$ , where  $R$  is  $-\text{C}(\text{CH}_3)=\text{CH-CH}_3$  or  $-\text{CH}_3$ ;

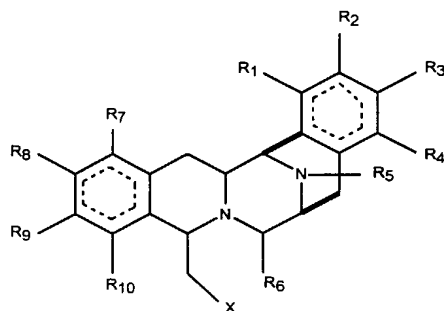
$R^5$  and  $R^8$  are independently chosen from  $-\text{H}$ ,  $-\text{OH}$  or  $-\text{OCOCH}_2\text{OH}$ , or  $R^5$  and  $R^8$  are both keto and the ring *A* is a p-benzoquinone ring;

$R^{14a}$  and  $R^{14b}$  are both  $-\text{H}$  or one is  $-\text{H}$  and the other is  $-\text{OH}$ ,  $-\text{OCH}_3$  or  $-\text{OCH}_2\text{CH}_3$ , or  $R^{14a}$  and  $R^{14b}$  together form a keto group;



$R^{15}$  and  $R^{18}$  are independently chosen from -H or -OH, or  $R^5$  and  $R^8$  are both keto and the ring *A* is a p-benzoquinone ring; and  $R^{21}$  is -OH or -CN.

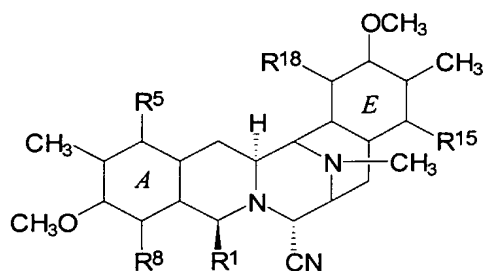
A more general formula for these class of compounds is provided below:



wherein the substituent groups defined by  $R_1$ ,  $R_2$ ,  $R_3$ ,  $R_4$ ,  $R_5$ ,  $R_6$ ,  $R_7$ ,  $R_8$ ,  $R_9$ ,  $R_{10}$  are each independently selected from the group consisting of H, OH,  $OCH_3$ , CN, =O,  $CH_3$ ; wherein X are the different amide or ester functionalities contained in the mentioned natural products; wherein each dotted circle represents one, two or three optional double bonds.

Thus, according to the present invention, we now provide hemisynthetic routes for the production of new and known compounds. The hemisynthetic routes of the invention each comprise a number of transformation steps to arrive at the desired product. Each step in itself is a process in accordance with this invention. The invention is not limited to the routes that are exemplified, and alternative routes may be provided by, for example, changing the order of the transformation steps, as appropriate.

In particular, this invention involves the provision of a 21-cyano starting material of general formula (XVI):



where  $R^1$ ,  $R^5$ ,  $R^8$ ,  $R^{14a}$ ,  $R^{14b}$ ,  $R^{15}$  and  $R^{18}$  are as defined.

Other compounds of formula (XVI) with different substituents at the 21-position may also represent possible starting materials. In general, any derivative capable of production by nucleophilic displacement of the 21-hydroxy group of compounds of formula (XV) wherein  $R^{21}$  is a hydroxy group is a candidate. Examples of suitable 21-substituents include but are not limited to:

a mercapto group;

an alkylthio group (the alkyl group having from 1 to 6 carbon atoms);

an arylthio group (the aryl group having from 6 to 10 carbon atoms and being unsubstituted or substituted by from 1 to 5 substituents selected from, for example, alkyl group having from 1 to 6 carbon atoms, alkoxy groups having from 1 to 6 carbon atoms, halogen atoms, mercapto groups and nitro groups);

an amino group;

a mono- or dialkylamino (the or each alkyl group having from 1 to 6 carbon atoms);

a mono- or diarylamino group (the or each aryl group being as defined above in relation to arylthio groups);

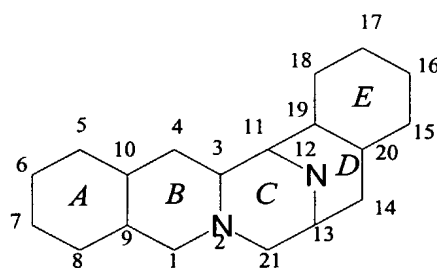
an  $\alpha$ -carbonylalkyl group of formula  $-C(R^a)(R^b)-C(=O)R^c$ , where

$R^a$  and  $R^b$  are selected from hydrogen atoms, alkyl groups having from 1 to 20 carbon atoms, aryl groups (as defined above in relation to arylthio groups) and aralkyl groups (in which an alkyl group having from 1 to 4 carbon atoms is substituted by an aryl group as defined above in relation to arylthio groups), with the proviso that one of  $R^a$  and  $R^b$  is a hydrogen atom;

$R^c$  is selected from a hydrogen atom, an alkyl group having from 1 to 20 carbon atoms, aryl groups (as defined above in relation to arylthio groups), an aralkyl group (in

which an alkyl group having from 1 to 4 carbon atoms is substituted by an aryl group a defined above in relation to arylthio groups), an alkoxy group having from 1 to 6 carbon atoms, an amino group or a mono- or dialkylamino group as defined above.

Thus, in a more general aspect, the present invention relates to processes where the first step is to form a 21-derivative using a nucleophilic reagent. We refer to such compounds as 21-Nuc compounds. Preferred starting material 21-Nuc compounds have the structure of formula (XIV):



where at least one ring *A* or *E* is quinolic.

Thus, in addition to the use of 21-cyano compounds, processes using other nucleophile-containing compounds, to produce similar compounds of formula (XVI) wherein the 21-position is protected by another nuclephilic group, a 21-Nuc group, are also envisaged. For example, a 21-Nuc compound of formula (XVI) with an alkylamino substituent at the 21-position can be produced by reacting the compound of formula (XV) wherein  $R^{21}$  is a hydroxy group with a suitable alkylamine. A 21-Nuc compound of formula (XVI) with an alkylthio substituent at the 21-position can also be produced by reacting the compound of formula (XV) wherein  $R^{21}$  is a hydroxy group with a suitable alkanethiol. Alternatively, a 21-Nuc compound of formula (XVI) with an  $\alpha$ -carbonylalkyl substituent at the 21-position can be produced by reacting the compound of formula (XV) wherein  $R^{21}$  is a hydroxy group with a suitable carbonyl compound, typically in the presence of a base. Other routes are available for other 21-Nuc compounds.

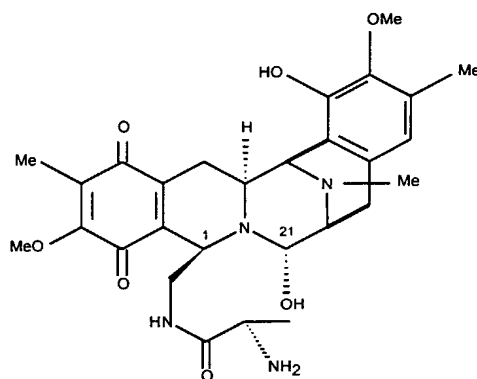
The presence of the 21-cyano group is required for some of the end-products, notably ecteinascidin 770 and phthalascidin, while for other end-products it acts as a protecting group which can readily be converted to another substituent, such as the 21-hydroxy group. The adoption of the 21-cyano compound as the starting material effectively stabilises the molecule during the ensuing synthetic steps, until it is optionally removed. Other 21-Nuc compounds can offer this and other advantages.

Preferred starting materials include those compounds of formula (XV) or (XVI) where  $R^{14a}$  and  $R^{14b}$  are both hydrogen. Preferred starting materials also include compounds of formula (XV) or (XVI) where  $R^{15}$  is hydrogen. Furthermore, the preferred starting materials include compounds of formula (XV) or (XVI) where ring *E* is a phenolic ring. Preferred starting materials further include compounds of formula (XV) or (XVI) where at least one, better at least two or three of  $R^5$ ,  $R^8$ ,  $R^{15}$  and  $R^{18}$  is not hydrogen.

Examples of suitable starting materials for this invention include saframycin A, saframycin B, saframycin C, saframycin G, saframycin H, saframycin S, saframycin Y<sub>3</sub>, saframycin Yd<sub>1</sub>, saframycin Ad<sub>1</sub>, saframycin Yd<sub>2</sub>, saframycin AH<sub>2</sub>, saframycin AH<sub>2</sub>Ac, saframycin AH<sub>1</sub>, saframycin AH<sub>1</sub>Ac, saframycin AR<sub>3</sub>, renieramycin A, renieramycin B, renieramycin C, renieramycin D, renieramycin E, renieramycin F, xestomycin, saframycin D, saframycin F, saframycin Mx-1, saframycin Mx-2, safracin A, safracin B and saframycin R. Preferred starting materials have a cyano group in position 21, for the group  $R^{21}$ .

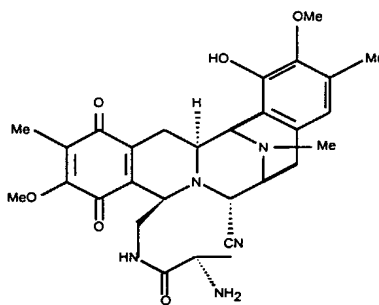
In a particularly preferred aspect, the invention involves a hemisynthetic process wherein the transformation steps are applied to safracin B:

44

SAFRACIN B

Safracin B presents a ring system closely related to the ecteinascidins. This compound has the same pentacycle structure and the same substitution pattern in the right-hand aromatic ring, ring *E*.

The more preferred starting materials of this invention have a 21-cyano group. The currently most preferred compound of the present invention is the compound of Formula 2. This compound is obtained directly from safracin B and is considered a key intermediate in the hemisynthetic process.



compound 2

Cyanosafracin B by fermentation of a safracin B-producing strain of *Pseudomonas fluorescens*, and working up the cultured broth using cyanide ion. The preferred strain of *Pseudomonas fluorescens* is strain A2-2, FERM BP-14, which is employed in the procedure of EP-A-055 299. A suitable source of cyanide ion is potassium cyanide. In a typical work-up, the broth is filtered and excess cyanide ion is

added. After an appropriate interval of agitation, such as 1 hour, the pH is rendered alkaline, say pH 9.5, and an organic extraction gives a crude extract which can be further purified to give the cyanosafracin B.

In general, the conversion of the 21-cyano starting compound to an product of this invention involves:

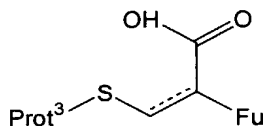
- a) conversion if necessary of a quinone system for the ring *E* into the phenol system
- b) conversion if necessary of a quinone system for the ring *A* into the phenol system;
- c) conversion of the phenol system for the ring *A* into the methylenedioxyphenol ring;
- d) formation of the bridged spiro ring system of formula (IV), (VI) or (VII) across the 1-position and 4-position in ring *B*; and
- e) derivatisation as appropriate, such as acylation.

Step (a), conversion if necessary of a quinone system for the ring *E* into the phenol system, can be effected by conventional reduction procedures. A suitable reagent system is hydrogen with a palladium-carbon catalyst, though other reducing systems can be employed.

Step (b), conversion if necessary of a quinone system for the ring *A* into the phenol system is analogous to step (a), and more detail is not needed.

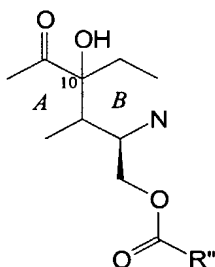
Step (c), conversion of the phenol system for the ring *A* into the methylenedioxyphenol ring, can be effected in several ways, possibly along with step (b). For example, a quinone ring *A* can be demethylated in the methoxy substituent at the 7-position and reduced to a dihydroquinone and trapped with a suitable electrophilic reagent such as  $\text{CH}_2\text{Br}_2$ ,  $\text{BrCH}_2\text{Cl}$ , or a similar divalent reagent directly yielding the methylenedioxy ring system, or with a divalent reagent such as thiocarbonyldiimidazol which yields a substituted methylenedioxy ring system which can be converted to the desired ring.

Step (d) is typically effected by appropriate substitution at the 1-position with a bridging reagent that can assist formation of the desired bridge, forming an exendo quinone methide at the 4-position and allowing the methide to react with the 1-substituent to bring about the bridged structure. Preferred bridging reagents are of formula (XIX)

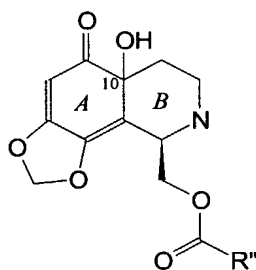


where Fu indicates a protected functional group, such as a group -NHProt<sup>4a</sup> or OProt<sup>4b</sup>, Prot<sup>3</sup> is a protecting group, and the dotted line shows an optional double bond.

Suitably the methide is formed by first introducing a hydroxy group at the 10-position at the junction of rings *A* and *B* to give a partial structure of formula (XX):



or more preferably a partial structure of formula (XXI):

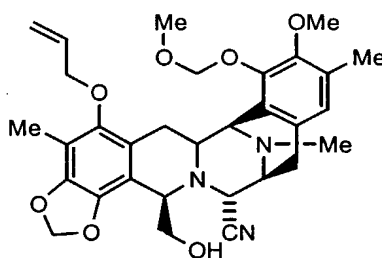


where the group R'' is chosen for the desired group of formula (IV), (V), (VI) or (VII). For the first two such groups, the group R'' typically takes the form -CHF<sub>u</sub>-CH<sub>2</sub>-SProt<sup>3</sup>. The protecting groups can then be removed and modified as appropriate to give the desired compound.

A typical procedure for step (d) is provided in US Patent 5,721,362 incorporated by reference. Particular reference is made to the passage at column 8, step (l) and Example 33 of the US Patent, and related passages.

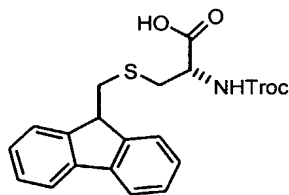
Derivatisation in step (e) can include acylation, for instance with a group  $R^a$ -CO- as well as conversion of the 12-NCH<sub>3</sub> group to 12-NH or 12-NCH<sub>2</sub>CH<sub>3</sub>. Such conversion can be effected before or after the other steps, using available methods.

By way of illustration, can be transformed into Intermediate **25**;

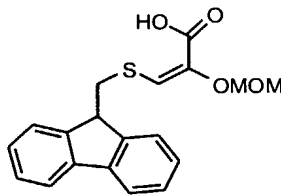


**INT-25**

and from this derivative it is possible to introduce a number of cysteine derivatives that can be transformed into compounds of this invention. Preferred cysteine derivatives are exemplified by the following two compounds:



**Int-29**

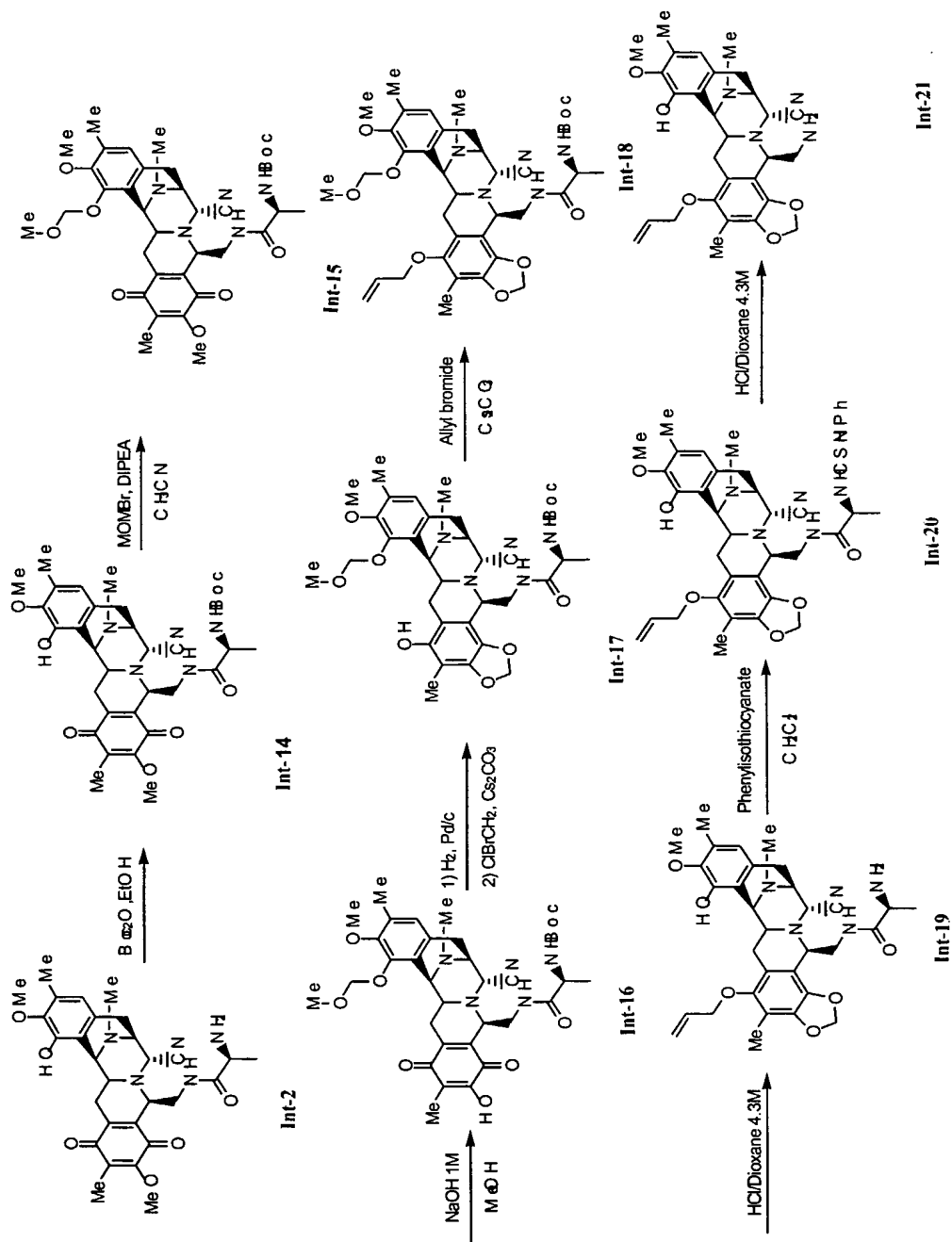


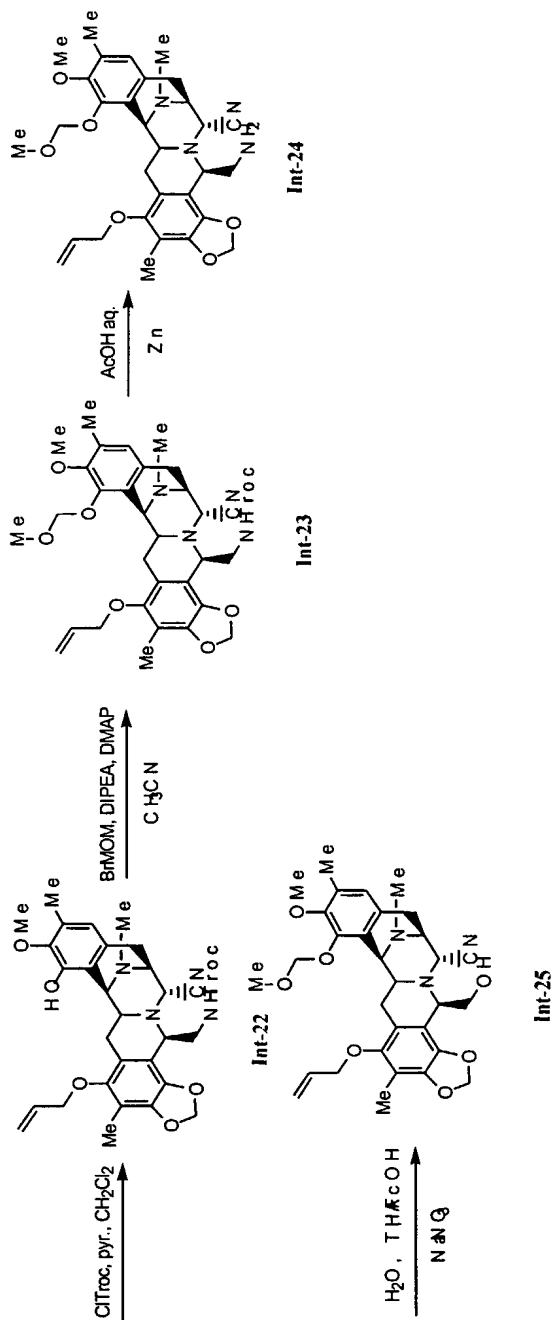
**Int-37**

One method of this invention transforms cyanosafracin B into intermediate **Int-25** through a sequence of reactions that involves essentially (1) removal of methoxy group placed in ring A, (2) reduction of ring A and formation of methylene-dioxy group in one pot, (3) hydrolysis of amide function placed over carbon 1, (4) transformation of the resulting amine group into hydroxyl group, see scheme V.



Scheme V





The method avoids protection and de-protection of the primary alcohol function at the position 1 in ring B of compound **Int-25** using directly a cysteine residue **Int-29** to form intermediate **Int-27**. Cysteine derivative **Int-29** is protected in the amino group with  $\beta$ - $\beta$ - $\beta$ -trichloroethoxycarbonyl protecting group in order to have compatibility with the existing allyl and MOM groups. Intermediate **Int-27** is directly oxidized and cycled. These circumstances, together with a different de-protecting strategy in the later stages of the synthesis makes the route novel and more amenable to industrial development than the process of US 5,721,362.

The conversion of the 2-cyano compound into Intermediate **Int-25** usually involves the following steps (see scheme V):

formation of the protected compound of Formula **Int-14** by reacting **Int-2** with *tert*-butoxycarbonyl anhydride;

converting of **Int-14** into the di-protected compound of Formula **Int-15** by reacting with bromomethylmethyl ether and diisopropylethylamine in acetonitrile;

selective elimination of the methoxy group of the quinone system in **Int-15** to obtain the compound of Formula **Int-16** by reacting with a methanolic solution of sodium hydroxide;

transforming of **Int-16** into the methylene-dioxy compound of Formula **Int-18** by employing the next preferred sequence: (1) quinone group of compound **Int-16** is reduced with 10% Pd/C under hydrogen atmosphere; (2) the hydroquinone intermediate is converted into the methylenedioxy compound of Formula **Int-17** by reacting with bromochloromethane and caesium carbonate under hydrogen atmosphere; (3) **Int-17** is transformed into the compound of Formula **Int-18** by protecting the free hydroxyl group as a OCH<sub>2</sub>R group. This reaction is carried out with BrCH<sub>2</sub>R and caesium carbonate, where R can be aryl, CH=CH<sub>2</sub>, OR' etc.

elimination of the *tert*-butoxycarbonyl and the methyloxymethyl protecting groups of **Int-18** to afford the compound of Formula **Int-19** by reacting with a solution of HCl in dioxane. Also this reaction is achieved by mixing **Int-18** with a solution of trifluoroacetic acid in dichloromethane;

formation of the thiourea compound of Formula **Int-20** by reacting **Int-19** with phenylisothiocyanate;

converting compound of Formula **Int-20** into the amine compound of Formula **Int-21** by reacting with a solution of hydrogen chloride in dioxane;

transforming compound of Formula **Int-21** into the *N*-Troc derivative **Int-22** by reacting with trichloroethyl chloroformate and pyridine;

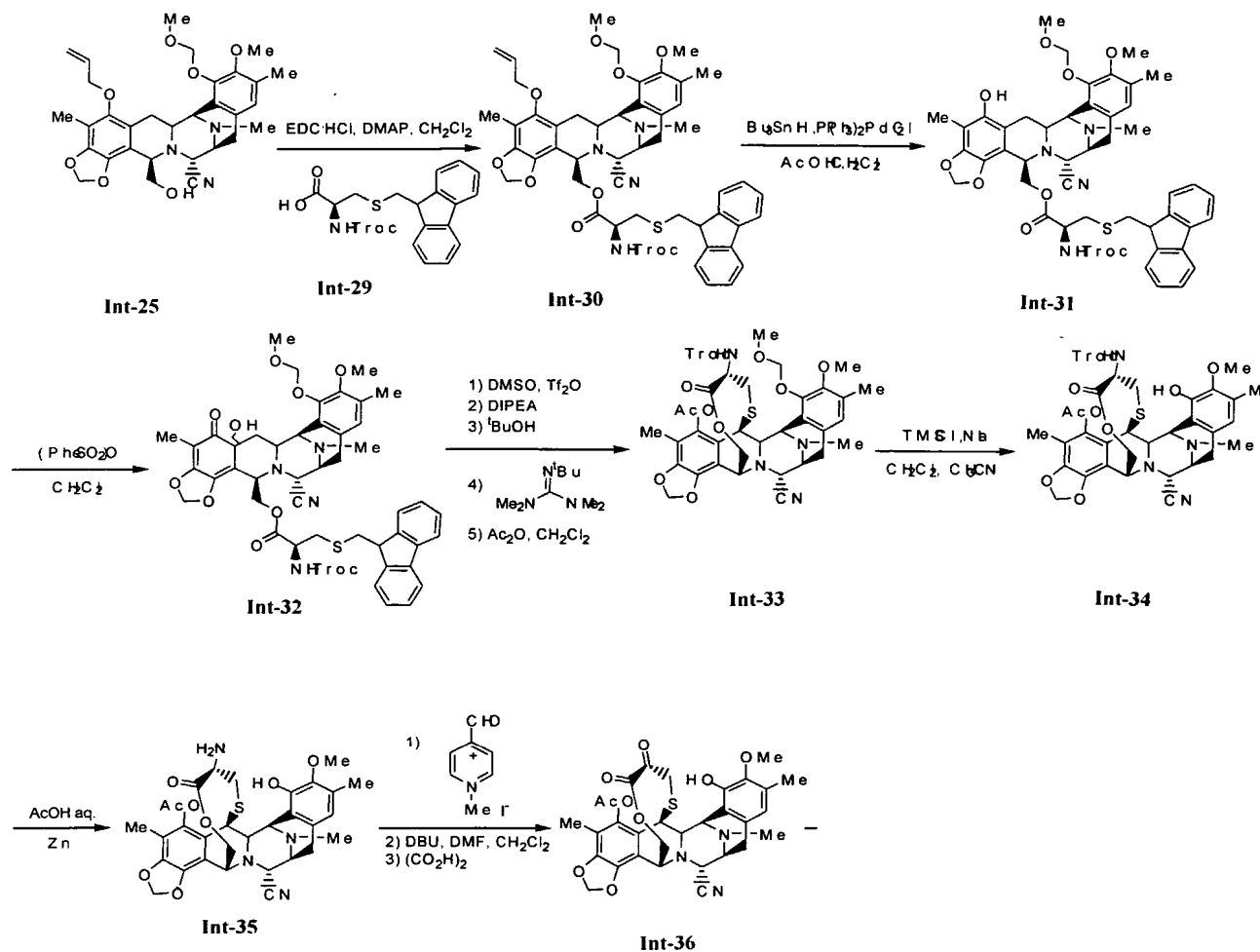
formation of the protected hydroxy compound of Formula **Int-23** by reacting **Int-22** with bromomethylmethyl ether and diisopropylethylamine;

transforming compound of Formula **Int-23** into the *N*-H derivative **Int-24** by reacting with acetic acid and zinc;

conversion of compound of Formula **Int-24** into the hydroxy compound of Formula **Int-25** by reaction with sodium nitrite in acetic acid. Alternatively, it can be used nitrogen tetroxide in a mixture of acetic acid and acetonitrile followed by treatment with sodium hydroxide. Also, it can be used sodium nitrite in a mixture of acetic anhydride-acetic acid, followed by treatment with sodium hydroxide.

From intermediate **Int-25** the conversion into final intermediate compounds **Int-35** or **Int-36** of this invention can then proceed as shown in Scheme VI:

## Scheme VI



transforming compound of formula **Int-24** into the derivative **Int-30** by protecting the primary hydroxyl function with (S)-N-2,2,2-trichloroethoxycarbonyl-S-(9H-fluoren-9-ylmethyl)cysteine **Int-29**;

converting the protected compound of formula **Int-30** into the phenol derivative **Int-31** by cleavage of the allyl group with tributyltin hydride and dichloropalladium-bis (triphenylphosphine);

transforming the phenol compound of Formula **Int-31** into compound of formula **Int-32** by oxidation with benzeneseleninic anhydride at low temperature;

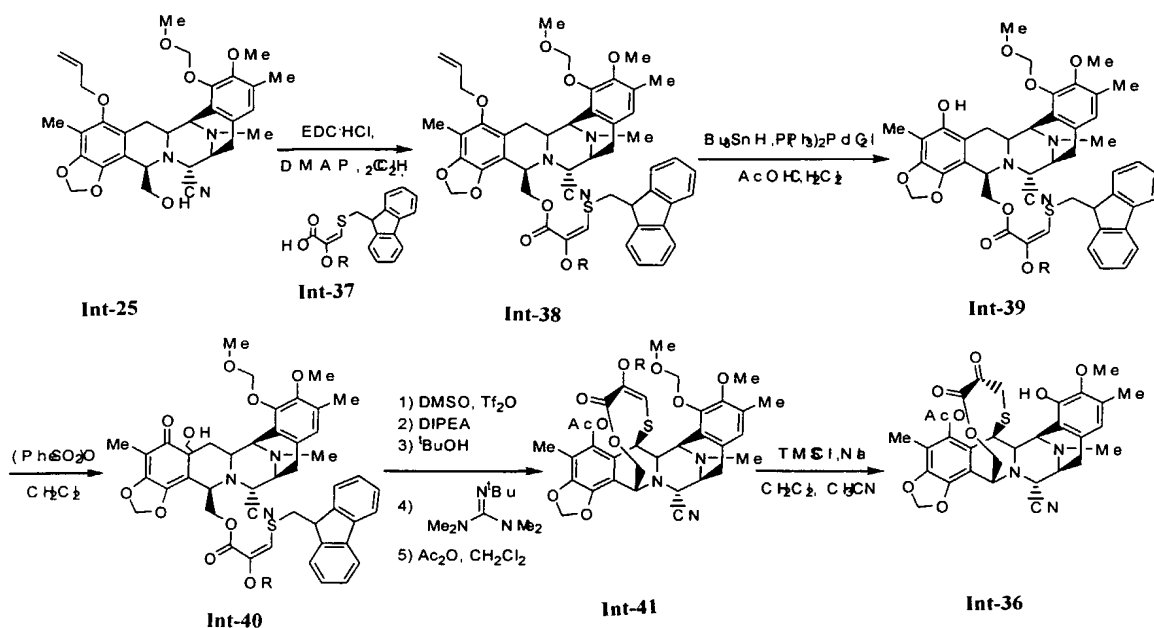
transforming the hydroxy compound of formula **Int-32** into the lactone **Int-33** by the following sequence: (1) Reacting compound of formula **Int-32** with 2 eq. of triflic anhydride and 5 eq. of DMSO. (2) followed by reaction with 8 eq. of diisopropylethylamine. (3) followed by reaction with 4 eq of t-butyl alcohol (4) followed by reaction with 7 eq of 2-*tert*-Butyl-1,1,3,3,tetramethylguanidine (5) followed by reaction with 10 eq of acetic anhydride;

transforming the lactone compound **Int-33** into hydroxyl compound **Int-34** by removal of MOM protecting group with TMSI;

cleaving the N-trichloroethoxycarbonyl group of the compound of formula **Int-34** into compound **Int-35** by reaction with Zn/AcOH;

transforming the amino compound **Int-35** into the corresponding  $\alpha$ -keto lactone compound **Int-36** by reaction with N-methyl pyridinium carboxaldehyde chloride followed by DBU;

The conversion of the Intermediate compound **Int-25** into ET-743 using cysteine derivative **Int-37** can be made in a similar manner and with the same reagents than with cysteine derivative **Int-29** with the exception of transformations (f) and (g). The reaction sequence is exemplified in the following Scheme VII:



Scheme VII

It will readily be appreciated that these synthetic routes can readily be modified, particularly by appropriate change of the starting material and reagents, so as to provide compounds of this invention with different fused ring systems or different substituents.

#### NOVEL ACTIVE COMPOUNDS

We have found that compounds of the invention have activity in the treatment of cancers, such as leukaemias, lung cancer, colon cancer, kidney cancer and melanoma.

Thus, the present invention provides a method of treating any mammal, notably a human, affected by cancer which comprises administering to the affected individual a therapeutically effective amount of a compound of the invention, or a pharmaceutical composition thereof.

The present invention also relates to pharmaceutical preparations, which contain as active ingredient a compound or compounds of the invention, as well as the processes for their preparation.

Examples of pharmaceutical compositions include any solid (tablets, pills, capsules, granules, etc.) or liquid (solutions, suspensions or emulsions) with suitable composition or oral, topical or parenteral administration, and they may contain the pure compound or in combination with any carrier or other pharmacologically active compounds. These compositions may need to be sterile when administered parenterally.

Administration of the compounds or compositions of the present invention may be by any suitable method, such as intravenous infusion, oral preparations, intraperitoneal and intravenous administration. We prefer that infusion times of up to 24 hours are used, more preferably 2-12 hours, with 2-6 hours most preferred. Short infusion times which allow treatment to be carried out without an overnight stay in hospital are especially desirable. However, infusion may be 12 to 24 hours or even longer if required. Infusion may be carried out at suitable intervals of say 2 to 4 weeks. Pharmaceutical compositions containing compounds of the invention may be delivered by liposome or nanosphere encapsulation, in sustained release formulations or by other standard delivery means.

The correct dosage of the compounds will vary according to the particular formulation, the mode of application, and the particular *situs*, host and tumour being treated. Other factors like age, body weight, sex, diet, time of administration, rate of excretion, condition of the host, drug combinations, reaction sensitivities and severity of the disease shall be taken into account. Administration can be carried out continuously or periodically within the maximum tolerated dose.

The compounds and compositions of this invention may be used with other drugs to provide a combination therapy. The other drugs may form part of the same composition, or be provided as a separate composition for administration at the same time or a different time. The identity of the other drug is not particularly limited, and suitable candidates include:



- a) drugs with antimitotic effects, especially those which target cytoskeletal elements, including microtubule modulators such as taxane drugs (such as taxol, paclitaxel, taxotere, docetaxel), podophylotoxins or vinca alkaloids (vincristine, vinblastine);
- b) antimetabolite drugs such as 5-fluorouracil, cytarabine, gemcitabine, purine analogues such as pentostatin, methotrexate);
- c) alkylating agents such as nitrogen mustards (such as cyclophosphamide or ifosfamide);
- d) drugs which target DNA such as the anthracycline drugs adriamycin, doxorubicin, pharmorubicin or epirubicin;
- e) drugs which target topoisomerases such as etoposide;
- f) hormones and hormone agonists or antagonists such as estrogens, antiestrogens (tamoxifen and related compounds) and androgens, flutamide, leuprorelin, goserelin, cyprotrone or octreotide;
- g) drugs which target signal transduction in tumour cells including antibody derivatives such as herceptin;
- h) alkylating drugs such as platinum drugs (cis-platin, carbonplatin, oxaliplatin, paraplalin) or nitrosoureas;
- i) drugs potentially affecting metastasis of tumours such as matrix metalloproteinase inhibitors;
- j) gene therapy and antisense agents;
- k) antibody therapeutics;
- l) other bioactive compounds of marine origin, notably the didemnins such as aplidine;
- m) steroid analogues, in particular dexamethasone;
- n) anti-inflammatory drugs, in particular dexamethasone; and
- o) anti-emetic drugs, in particular dexamethasone.

The present invention also extends to the compounds of the invention for use in a method of treatment, and to the use of the compounds in the preparation of a composition for treatment of cancer.

## CYTOTOXIC ACTIVITY

Cell Cultures. Cells were maintained in logarithmic phase of growth in Eagle's Minimum Essential Medium, with Earle's Balanced Salts, with 2.0 mM L-glutamine, with non-essential amino acids, without sodium bicarbonate (EMEM/nea); supplemented with 10% Fetal Calf Serum (FCS),  $10^{-2}$  M sodium bicarbonate and 0.1 g/l penicillin-G + streptomycin sulfate.

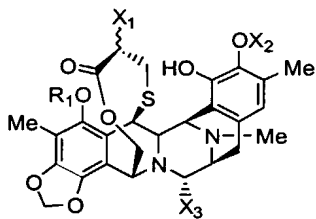
A simple screening procedure has been carried out to determine and compare the antitumour activity of these compounds, using an adapted form of the method described by Bergeron et al (1984). The tumour cell line employed have been P-388 (suspension culture of a lymphoid neoplasm from DBA/2 mouse), A-549 (monolayer culture of a human lung carcinoma), HT-29 (monolayer culture of a human colon carcinoma) and MEL-28 (monolayer culture of a human melanoma).

P-388 cell were seeded into 16 mm wells at  $1 \times 10^4$  cells per well in 1 ml aliquots of MEM 5FCS containing the indicated concentration of drug. A separate set of cultures without drug was seeded as control growth to ensure that cells remained in exponential phase of growth. All determinations were carried out in duplicate. After three days of incubation at 37°C, 10% CO<sub>2</sub> in a 98% humid atmosphere, an approximately IC<sub>50</sub> was determined by comparing the growth in wells with drug to the growth in wells control.

A-549, HT-29 and MEL-28 were seeded into 16 mm wells at  $2 \times 10^4$  cells per well in 1 ml aliquots of MEM 10FCS containing the indicated concentration of drug. A separate set of cultures without drug was seeded as control growth to ensure that cells remained in exponential phase of growth. All determinations were carried out in duplicate. After three days of incubation at 37°C, 10% CO<sub>2</sub> in a 98% humid atmosphere, the wells were stained with 0.1% Crystal Violet. An approximately IC<sub>50</sub> was determined by comparing the growth in wells with drug to the growth in wells control.

1. Raymond J. Bergeron, Paul F. Cavanaugh, Jr., Steven J. Kline. Robert G. Hughes, Jr., Gary T. Elliot and Carl W. Porter. Antineoplastic and antiherpetic activity of spermidine catecholamide iron chelators. *Biochem. Bioph. Res. Comm.* 1984, 121(3), 848-854.
2. Alan C. Schroeder, Robert G. Hughes, Jr. and Alexander Bloch. Effects of Acyclic Pyrimidine Nucleoside Analogues. *J. Med. Chem.* 1981, 24 1078-1083.

Examples of biological activities of the compounds described in the present application are in Table IV (IC<sub>50</sub> (ng/mL)) on the following pages.



Compound	X <sub>1</sub>	X <sub>2</sub>	X <sub>3</sub>	R <sub>1</sub>	P-388	A-549	HT-29	MEL-28	DU-145
4a	AcNH-	Me	OH	Ac	0.1	0.5	0.1	0.5	0.1
4b	F <sub>3</sub> CCONH-	Me	OH	Ac	0.5	0.5	0.5	0.5	0.5
4c	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>2</sub> CONH-	Me	OH	Ac	0.1	0.1	0.1	0.1	0.1
4d	(CH <sub>3</sub> ) <sub>2</sub> CHCH <sub>2</sub> CONH-	Me	OH	Ac	0.5	0.5	0.5	0.5	0.5
4e	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>6</sub> CONH-	Me	OH	Ac	1.0	1.0	1.0	1.0	1.0
4f	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>14</sub> CONH-	Me	OH	Ac	100	100	100	100	100
4g	PhCONH-	Me	OH	Ac	0.1	0.5	0.5	0.5	0.5
4h	CinnCONH-	Me	OH	Ac	0.5	0.5	0.5	0.5	0.5
4i	p-F <sub>3</sub> C-CinnCONH-	Me	OH	Ac	1.0	1.0	1.0	1.0	1.0
4k	BiotinCONH-	Me	OH	Ac	10	10	10	10	10
4l	HO <sub>2</sub> CCH <sub>2</sub> CH <sub>2</sub> CONH-	Me	OH	Ac	100	100	100	100	100
4n	BnNH-	Me	OH	Ac	0.5	0.5	0.5	0.5	0.5
4o	PrNH-	Me	OH	Ac		1.0	1.0		
4p	NH <sub>2</sub> -ValCONH-	Me	OH	Ac	0.5	0.5	0.5	0.5	0.5
4q	Ac-N-ValCONH-	Me	OH	Ac	1.0	1.0	1.0	1.0	1.0
4r	CinnCO-N-ValCONH-	Me	OH	Ac	0.5	0.5	0.5	0.5	0.5
4s	NH <sub>2</sub> -Ala-ValCONH-	Me	OH	Ac	1.0	1.0	1.0	1.0	1.0
4t	Ac-N-Ala-ValCONH-	Me	OH	Ac	100	100	10	10	10
4u	CinnCO-N-Ala-ValCONH-	Me	OH	Ac	5.0	5.0	5.0	5.0	5.0
4v	NH <sub>2</sub> -AlaCONH-	Me	OH	Ac	1.0	1.0	1.0	1.0	1.0
4x	CinnCO-N-AlaCONH-	Me	OH	Ac	1.0	1.0	1.0	1.0	1.0
4y	FmSCH <sub>2</sub> CH(NHAlloC)CONH-	Me	OH	Ac	50	50	50	50	50
19	HO-	Me	OH	Ac	1.0	1.0	1.0	1.0	1.0

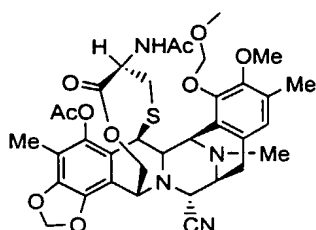
21a	AcO-	Me	OH	Ac	0.5	1.0	1.0	1.0	1.0	1.0	1.0
21c	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>2</sub> COO-	Me	OH	Ac	1.0	1.0	1.0	1.0	1.0	1.0	1.0
21e	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>6</sub> COO-	Me	OH	Ac	1.0	1.0	1.0	1.0	1.0	1.0	1.0
21f	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>14</sub> COO-	Me	OH	Ac		>1000	>1000				
21h	CinnCOO-	Me	OH	Ac	1.0	1.0	1.0	1.0	1.0	1.0	1.0
21l	MeSO <sub>3</sub> -	Me	OH	Ac	1.0	1.0	1.0	1.0	1.0	1.0	1.0
22a*	*AcO-	Me	OH	Ac		1.0	1.0				
27	NH <sub>2</sub>	Me	CN	Ac	5.0	5.0	5.0	5.0	5.0		--
23	NH <sub>2</sub>	Me	CN	H		10	10				
24	NH <sub>2</sub>	H	CN	Ac		100	100				
3a	AcNH-	Me	CN	Ac	0.5	0.5	0.5	0.5	0.5	0.5	0.5
25	AcNH-	Me	CN	H		10	10				
26	AcNH-	H	CN	Ac		100	100				
3b	F <sub>3</sub> CCONH-	Me	CN	Ac	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3c	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>2</sub> CONH-	Me	CN	Ac	0.1	0.1	0.1	0.1	0.1	0.1	0.1
3d	(CH <sub>3</sub> ) <sub>2</sub> CHCH <sub>2</sub> CONH-	Me	CN	Ac	0.1	0.1	0.1	0.1	0.1	0.1	0.1
3e	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>6</sub> CONH-	Me	CN	Ac	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3f	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>14</sub> CONH-	Me	CN	Ac	>1·10 <sup>3</sup>	>1·10 <sup>3</sup>	>1·10 <sup>3</sup>	>1·10 <sup>3</sup>	>1·10 <sup>3</sup>	>1·10 <sup>3</sup>	>1·10 <sup>3</sup>
3g	PhCONH-	Me	CN	Ac	0.1	0.1	0.1	0.1	0.1	0.1	0.1
3h	CinnCONH-	Me	CN	Ac	0.5	0.5	0.5	0.5	0.5	0.5	0.5
3i	p-F <sub>3</sub> C-CinnCONH-	Me	CN	Ac	5.0	5.0	5.0	5.0	5.0	5.0	5.0
3j	PhN-	Me	CN	Ac	5	5	5	5	5	5	5
6	2-MeO <sub>2</sub> C-C <sub>6</sub> H <sub>4</sub> -CONH-	Me	CN	Ac	1	1	1	1	1	1	1
3k	BiotinNH-	Me	CN	Ac	10	10	10	10	10	10	10
3l	HO <sub>2</sub> C(CH <sub>2</sub> ) <sub>2</sub> CONH-	Me	CN	Ac	100	100	100	100	100	100	100

3m	(CH <sub>3</sub> ) <sub>2</sub> N-	Me	CN	Ac	10	10	10	10	10	10
3n	BnNH-	Me	CN	Ac	0.5	0.5	0.5	0.5	0.5	0.5
3o	PrNH-	Me	CN	Ac		5	5			
3p	NH <sub>2</sub> -ValCONH-	Me	CN	Ac	1	1	1	1	1	1
3q	Ac-N-ValCONH-	Me	CN	Ac	1	1	1	1	1	1
3r	CinnCO-N-ValCONH-	Me	CN	Ac	1	1	1	1	1	1
3s	NH <sub>2</sub> -Ala-ValCONH-	Me	CN	Ac	1	1	1	1	1	1
3t	Ac-N-Ala-ValCONH-	Me	CN	Ac	10	10	10	10	10	10
3u	CinnCO-N-Ala-ValCONH-	Me	CN	Ac	5	5	1	1	1	1
3v	NH <sub>2</sub> -AlaCONH-	Me	CN	Ac	1	1	1	1	1	1
3w	Ac-N-AlaCONH-	Me	CN	Ac	1	1	1	1	1	1
3x	CinnCO-N-AlaCONH-	Me	CN	Ac	0.1	0.1	0.1	0.1	0.1	0.1
3y	FmSCH <sub>2</sub> CH(NHAlloC)CONH-	Me	CN	Ac	10	10	10	10	50	50
3z	FmSCH <sub>2</sub> CH(NH <sub>2</sub> )CONH-	Me	CN	Ac	50	50	50	50	50	50
28	Cl <sub>3</sub> CCH <sub>2</sub> OCONH-	Me	CN	Ac	1.0	1.0	1.0	1.0	1.0	1.0
15	HO-	Me	CN	Ac	5	5	5	5	5	5
16*	*HO-	Me	CN	Ac		10	10			
17a	AcO-	Me	CN	Ac	0.1	0.1	0.1	0.1	0.1	0.1
17b	F <sub>3</sub> CCOO-	Me	CN	Ac	5.0	5.0	5.0	5.0	5.0	5.0
17c	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>2</sub> COO-	Me	CN	Ac	1.0	1.0	1.0	1.0	1.0	1.0
17e	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>6</sub> COO-	Me	CN	Ac	1.0	1.0	1.0	1.0	1.0	1.0
17f	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>14</sub> COO-	Me	CN	Ac	>1000	>1000	>1000	>1000	>1000	>1000
17h	CinnCOO-	Me	CN	Ac	0.1	0.1	0.1	0.1	0.1	0.1
17II	MeSO <sub>3</sub> -	Me	CN	Ac	1	1	1	1	1	--
18a*	*AcO-	Me	CN	Ac	1.0	1.0	1.0	1.0	1.0	1.0

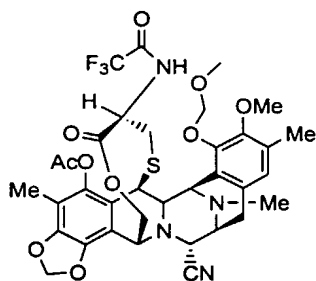
## EXAMPLES

## Example 1

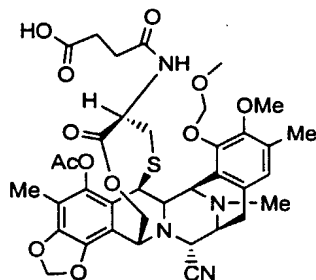
**Method A:** To a solution of 1 equiv. of **1** (**23** for **25**) coevaporated with anhydrous toluene in  $\text{CH}_2\text{Cl}_2$  (0.08M) under Argon were added 1.2 equiv. of the anhydride. The reaction was followed by TLC and quenched with acid or base, extracted with  $\text{CH}_2\text{Cl}_2$  and the organic layers dried with  $\text{Na}_2\text{SO}_4$ . Flash chromatography gives pure compounds.



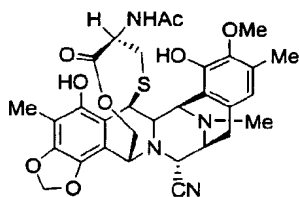
Compound **2a** (using  $\text{Ac}_2\text{O}$  as the anhydride):  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.77 (s, 1H), 6.04 (dd, 2H), 5.53 (bd, 1H), 5.18 (dd, 2H), 5.02 (d, 1H), 4.58 (ddd, 1H), 4.52 (bs, 1H), 4.35 (d, 1H), 4.27 (s, 1H), 4.19-4.15 (m, 2H), 3.75 (s, 3H), 3.55 (s, 3H), 3.54-3.43 (m, 2H), 2.93 (bd, 2H), 2.35-2.02 (m, 2H), 2.28 (s, 3H), 2.27 (s, 3H), 2.18 (s, 3H), 2.02 (s, 3H), 1.89 (s, 3H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  170.5, 168.7, 168.4, 149.7, 148.5, 145.8, 141.0, 140.4, 131.0, 130.5, 125.7, 124.5, 120.3, 117.9, 113.5, 113.4, 102.0, 99.1, 61.4, 60.3, 59.6, 58.8, 55.0, 54.5, 52.1, 41.8, 41.3, 32.6, 23.7, 20.9, 20.2, 16.1, 9.5; ESI-MS  $m/z$ : Calcd. for  $\text{C}_{35}\text{H}_{40}\text{N}_4\text{O}_{10}\text{S}$ : 708.2. Found ( $\text{M}+\text{H}^+$ ): 709.2.



Compound **2b** (using  $(\text{F}_3\text{CCO})_2\text{O}$  as the anhydride):  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.74 (s, 1H), 6.41 (bd, 1H), 6.05 (dd, 2H), 5.17 (dd, 2H), 5.05 (d, 1H), 4.60 (bp, 1H), 4.54-4.51 (m, 1H), 4.36-4.32 (m, 2H), 4.25-4.19 (m, 2H), 3.72 (s, 3H), 3.56 (s, 3H), 3.48-3.43 (m, 2H), 2.99-2.82 (m, 2H), 2.46-2.41 (m, 1H), 2.30-2.03 (m, 1H), 2.29 (s, 3H), 2.24 (s, 3H), 2.17 (s, 3H), 2.04 (s, 3H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  168.9, 168.5, 156.3, 155.8, 155.3, 149.3, 148.5, 146.0, 141.2, 140.6, 132.0, 130.2, 124.8, 120.2, 117.9, 113.2, 102.1, 99.2, 61.5, 60.6, 59.7, 59.1, 58.7, 57.5, 54.9, 54.6, 52.9, 42.0, 41.4, 31.6, 23.8, 20.2, 14.1, 9.6; ESI-MS  $m/z$ : Calcd. for  $\text{C}_{35}\text{H}_{37}\text{F}_3\text{N}_4\text{O}_{10}\text{S}$ : 762.2. Found ( $\text{M}+\text{H}^+$ ): 763.2.



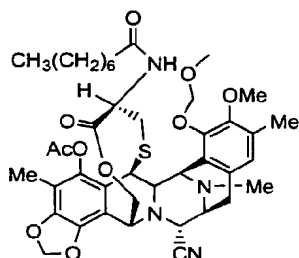
Compound **2l** (using succinic anhydride):  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.79 (s, 1H), 6.04 (dd, 2H), 5.63 (bd, 1H), 5.18 (dd, 2H), 5.02 (d, 1H), 4.59-4.53 (m, 2H), 4.35 (d, 1H), 4.28 (s, 1H), 4.21-4.17 (m, 2H), 3.76 (s, 3H), 3.57 (s, 3H), 3.54-3.44 (m, 2H), 2.92 (bd, 2H), 2.69-2.63 (m, 2H), 2.53-2.48 (m, 2H), 2.38-2.07 (m, 2H), 2.28 (s, 6H), 2.18 (s, 3H), 2.02 (s, 3H); ESI-MS  $m/z$ : Calcd. for  $\text{C}_{37}\text{H}_{42}\text{N}_4\text{O}_{12}\text{S}$ : 766.2. Found ( $\text{M}+\text{H}^+$ ): 767.3.



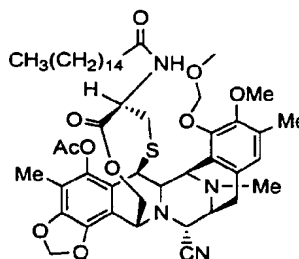
Compound **25** (from Compound **23** using 1 equiv of Ac<sub>2</sub>O as the anhydride): <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 6.59 (s, 1H), 5.97 (dd, 2H), 5.87 (s, 1H), 5.53 (s, 1H), 5.51 (d, 1H), 5.00 (d, 1H), 4.62-4.58 (m, 1H), 4.44 (s, 1H), 4.31 (s, 1H), 4.29 (d, 1H), 4.16 (d, 1H), 4.09 (dd, 1H), 3.79 (s, 3H), 3.54-3.52 (m, 1H), 3.44-3.42 (m, 1H), 2.93-2.91 (m, 2H), 2.46 (dd, 1H), 2.33 (s, 3H), 2.23 (dd, 1H), 2.15 (s, 3H), 2.14 (s, 3H), 1.90 (s, 1H); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 170.1, 169.0, 148.3, 146.4, 146.0, 143.0, 136.4, 130.7, 129.2, 120.4, 119.0, 118.1, 112.4, 112.3, 107.8, 101.4, 61.1, 60.5, 59.2, 58.8, 54.7, 54.5, 51.6, 43.3, 41.4, 31.4, 23.8, 22.9, 16.2, 8.7; ESI-MS m/z: Calcd. for C<sub>31</sub>H<sub>34</sub>N<sub>4</sub>O<sub>8</sub>S: 580.2. Found (M+H<sup>+</sup>): 581.3.

## Example 2

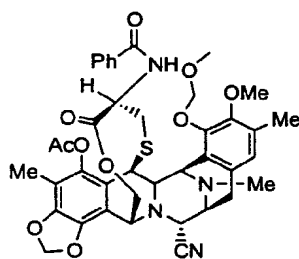
**Method B:** To a solution of 1 equiv. of **1** (**2p** for **2t** and **9**, and **11** for **13e-f**) and 1.5 equiv. of acid coevaporated twice with anhydrous toluene in CH<sub>2</sub>Cl<sub>2</sub> (0.05M) under Argon, were added 2 equiv. of DMAP and 2 equiv. of EDC·HCl. The reaction was stirred for 3h 30 min. After this time was diluted with CH<sub>2</sub>Cl<sub>2</sub>, washed with brine and the organic layer dried with Na<sub>2</sub>SO<sub>4</sub>. Flash chromatography gives pure compounds.



Compound **2e** (using CH<sub>3</sub>(CH<sub>2</sub>)<sub>6</sub>CO<sub>2</sub>H as the acid): <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 6.76 (s, 1H), 6.04 (dd, 2H), 5.50 (bd, 1H), 5.18 (dd, 2H), 5.02 (d, 1H), 4.60 (ddd, 1H), 4.53 (bp, 1H), 4.35 (d, 1H), 4.28 (s, 1H), 4.19 (d, 1H), 4.18 (dd, 1H), 3.76 (s, 3H), 3.58 (s, 3H), 3.48-3.43 (m, 2H), 2.93 (bd, 2H), 2.29-1.99 (m, 4H), 2.29 (s, 3H), 2.28 (s, 3H), 2.17 (s, 3H), 2.03 (s, 3H), 1.31-1.23 (m, 10H), 0.89 (t, 3H); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 171.9, 170.6, 168.4, 149.6, 148.5, 145.8, 141.0, 140.4, 130.9, 130.5, 125.7, 124.5, 120.4, 117.9, 113.4, 102.0, 99.2, 61.5, 60.2, 59.6, 59.3, 58.7, 57.5, 55.0, 54.5, 51.9, 41.8, 41.4, 36.4, 32.7, 31.7, 29.3, 29.1, 25.4, 23.7, 22.6, 20.3, 16.1, 14.0, 9.6; ESI-MS m/z: Calcd. for C<sub>41</sub>H<sub>52</sub>N<sub>4</sub>O<sub>10</sub>S: 792.3. Found (M+H<sup>+</sup>): 793.3.



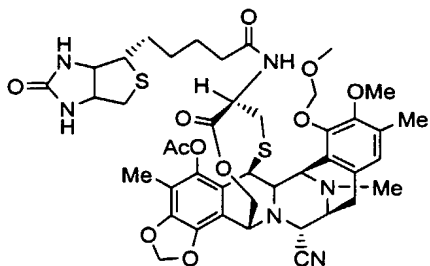
Compound **2f** (using CH<sub>3</sub>(CH<sub>2</sub>)<sub>14</sub>CO<sub>2</sub>H as the acid): <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 6.76 (s, 1H), 6.05 (dd, 2H), 5.50 (bd, 1H), 5.18 (dd, 2H), 5.02 (d, 1H), 4.60 (ddd, 1H), 4.56-4.50 (bp, 1H), 4.35 (d, 1H), 4.28 (bs, 1H), 4.20 (d, 1H), 4.18 (dd, 1H), 3.76 (s, 3H), 3.57 (s, 3H), 3.54-3.44 (m, 2H), 2.93-2.92 (bd, 2H), 2.37-2.01 (m, 4H), 2.29 (s, 3H), 2.28 (s, 3H), 2.18 (s, 3H), 2.03 (s, 3H), 1.60-1.56 (m, 2H), 1.40-1.20 (m, 24H), 0.88 (t, 3H); ESI-MS m/z: Calcd. for C<sub>49</sub>H<sub>68</sub>N<sub>4</sub>O<sub>10</sub>S: 904.5. Found (M+H<sup>+</sup>): 905.5.



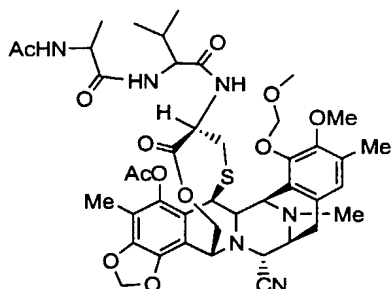
Compound **2g** (using PhCO<sub>2</sub>H as the acid): <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 7.69-7.66 (m, 2H), 7.57-7.46 (m, 3H), 6.69 (s, 1H), 6.35 (d, 1H), 6.06 (dd, 2H), 5.14 (dd, 2H), 5.07 (d, 1H), 4.76 (dt, 1H), 4.58 (bp, 1H), 4.36-4.33 (m, 2H), 4.24-



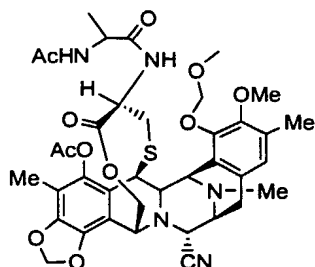
4.18 (m, 2H), 3.62 (s, 3H), 3.55 (s, 3H), 3.49-3.46 (m, 2H), 2.94 (bd, 2H), 2.62-2.55 (m, 1H), 2.28-1.93 (m, 1H), 2.28 (s, 3H), 2.16 (s, 3H), 2.04 (s, 3H), 1.93 (s, 3H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  170.5, 168.4, 166.4, 149.3, 148.4, 145.9, 141.1, 140.6, 134.5, 134.2, 131.6, 131.4, 130.5, 128.6, 126.9, 125.2, 124.5, 120.7, 118.0, 113.4, 102.0, 99.2, 61.6, 60.2, 59.8, 59.2, 58.6, 57.4, 55.0, 54.6, 53.2, 41.9, 41.4, 32.9, 23.9, 20.2, 15.7, 9.6; ESI-MS  $m/z$ : Calcd. for  $\text{C}_{40}\text{H}_{42}\text{N}_4\text{O}_{10}\text{S}$ : 770.3. Found ( $\text{M}+\text{H}^+$ ): 771.3.



Compound **2k** (using (+)-biotin as the acid):  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.78 (s, 1H), 6.04 (dd, 2H), 6.00 (s, 1H), 5.80 (s, 1H), 5.39 (bd, 1H), 5.18 (dd, 3H), 4.78 (d, 1H), 4.64-4.51 (m, 3H), 4.34-4.28 (m, 3H), 4.19 (dd, 1H), 3.77 (s, 3H), 3.57 (s, 3H), 3.47-3.39 (m, 2H), 3.19-3.13 (m, 1H), 3.02-2.74 (m, 4H), 2.28-1.47 (m, 10H), 2.28 (s, 6H), 2.14 (s, 3H), 2.02 (s, 3H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  172.3, 171.3, 165.6, 163.7, 149.6, 148.4, 145.9, 141.0, 140.5, 131.1, 130.7, 125.8, 124.8, 120.2, 118.4, 113.7, 113.3, 102.0, 99.1, 61.5, 61.4, 61.3, 60.0, 59.6, 59.3, 58.4, 57.4, 56.1, 55.2, 54.6, 51.8, 42.2, 41.3, 41.1, 35.2, 32.1, 28.2, 28.1, 25.4, 24.0, 20.3, 16.1, 9.5; ESI-MS  $m/z$ : Calcd. for  $\text{C}_{43}\text{H}_{52}\text{N}_6\text{O}_{11}\text{S}_2$ : 892.3. Found ( $\text{M}+\text{H}^+$ ): 894.1.



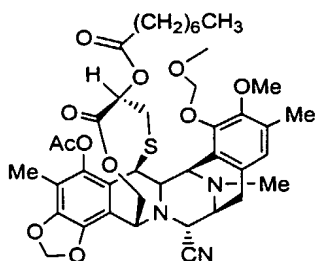
Compound **2t** (from Compound **2p** using Ac-L-alanine as the acid):  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.74 (s, 1H), 6.60-6.56 (m, 1H), 6.26 (bt, 1H), 6.04 (dd, 2H), 5.58 (bt, 1H), 5.17 (dd, 2H), 5.00 (d, 1H), 4.64-4.60 (m, 1H), 4.56 (bp, 1H), 4.48 (dt, 1H), 4.35 (d, 1H), 4.29 (s, 1H), 4.20-4.14 (m, 2H), 4.12-4.05 (m, 1H), 3.75, 3.76 (2s, 3H), 3.56 (s, 3H), 3.47-3.42 (m, 2H), 2.98-2.89 (m, 2H), 2.42-1.98 (m, 3H), 2.42 (s, 3H), 2.28 (s, 3H), 2.16 (s, 3H), 2.02 (s, 3H), 1.98 (s, 3H), 1.36, 1.33 (2d, 3H), 1.06, 1.03 (2d, 3H), 0.94, 0.93 (2d, 3H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  171.9, 170.2, 169.6, 169.7, 168.5, 149.6, 148.6, 145.9, 141.1, 140.5, 131.8, 130.3, 125.4, 124.4, 120.3, 117.9, 113.4, 102.0, 99.2, 61.5, 60.2, 59.6, 59.4, 59.3, 58.5, 57.8, 57.7, 57.4, 54.9, 54.5, 52.0, 51.9, 48.9, 48.8, 42.0, 41.3, 32.7, 32.2, 32.1, 23.8, 23.1, 23.1, 20.3, 19.2, 19.2, 19.1, 18.4, 17.7, 17.7, 16.2, 9.5. ESI-MS  $m/z$ : Calcd. for  $\text{C}_{43}\text{H}_{54}\text{N}_6\text{O}_{12}\text{S}$ : 878.3. Found ( $\text{M}+\text{H}^+$ ): 879.2.



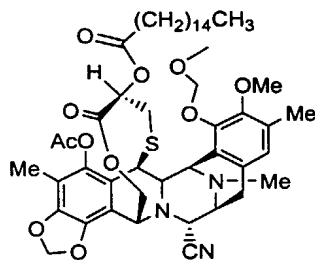
Compound **2w** (using Ac-L-alanine as the acid):  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.89, 6.77 (2s, 1H), 6.25 (dd, 1H), 6.05 (dd, 2H), 5.72, 5.55 (2bd, 1H), 5.22-5.13 (2dd, 2H), 5.02, 5.01 (2d, 1H), 4.60-4.18 (m, 7H), 3.77, 3.74 (2s, 3H), 3.56 (s, 3H), 3.48-3.43 (m, 2H), 2.93-2.91 (bd, 2H), 2.42-1.98 (m, 2H), 2.42, 2.37 (2s, 3H), 2.29, 2.28 (2s, 3H), 2.17, 2.15 (2s, 3H), 2.03 (s, 3H), 1.99, 1.97 (2s, 3H), 1.46, 1.22 (2d, 3H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  171.5, 170.1, 169.9, 169.3, 169.2, 168.6, 149.8, 149.4, 148.7, 148.5, 145.9, 141.1, 140.5, 140.4, 132.0, 131.6, 130.6, 130.2, 125.5, 124.9, 124.4, 120.4, 120.2, 117.9, 113.6, 113.4, 102.0, 99.2, 61.6, 61.5, 60.4, 60.3, 59.6, 59.5, 59.4, 59.2, 58.8, 58.3, 57.5, 55.0, 55.0, 54.6, 52.2, 51.8, 48.6,



3H), 2.02 (s, 3H), 1.41 (s, 9H), 1.32 (d, 3H), 1.03 (d, 3H), 0.93 (d, 3H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  172.1, 170.2, 169.7, 168.5, 149.7, 148.7, 145.9, 141.0, 140.5, 132.0, 130.2, 125.3, 124.4, 120.3, 117.9, 113.5, 102.0, 99.2, 61.5, 60.2, 59.6, 59.4, 58.5, 57.7, 57.4, 55.0, 54.6, 51.9, 50.2, 42.0, 41.4, 32.7, 32.2, 28.2, 23.8, 20.3, 19.1, 18.1, 17.8, 16.3, 9.6. ESI-MS  $m/z$ : Calcd. for  $\text{C}_{46}\text{H}_{60}\text{N}_6\text{O}_{13}\text{S}$ : 936.4. Found ( $\text{M}^+$ ): 937.2.



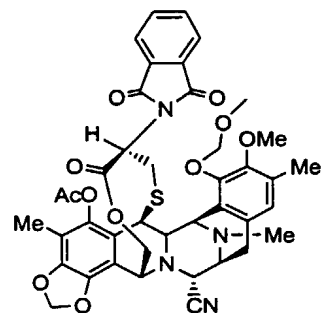
Compound 13e (using 5 equiv. of  $\text{CH}_3(\text{CH}_2)_6\text{CO}_2\text{H}$  as the acid, 7 equiv. of DMAP and 7 equiv. of EDC·HCl):  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.68 (s, 1H), 6.04 (dd, 2H), 5.17 (dd, 2H), 5.02-4.98 (m, 2H), 4.56 (bp, 1H), 4.34 (d, 1H), 4.28 (s, 1H), 4.19 (d, 1H), 4.11 (dd, 1H), 3.78 (s, 3H), 3.56 (s, 3H), 3.46 (d, 1H), 3.42-3.39 (m, 1H), 2.89-2.87 (m, 2H), 2.32-1.96 (m, 4H), 2.30 (s, 3H), 2.26 (s, 3H), 2.17 (s, 3H), 2.03 (s, 3H), 1.60-1.55 (m, 2H), 1.32-1.23 (m, 8H), 0.90 (t, 3H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  172.5, 168.6, 167.1, 148.9, 148.2, 145.8, 141.1, 140.6, 130.7, 125.3, 125.1, 124.7, 120.9, 118.1, 113.6, 113.1, 102.0, 99.2, 71.4, 61.5, 60.0, 59.8, 59.2, 58.6, 57.4, 55.0, 54.6, 41.6, 41.5, 33.8, 31.7, 29.1, 28.9, 24.7, 23.9, 22.6, 20.2, 15.9, 14.0, 9.6. ESI-MS  $m/z$ : Calcd. for  $\text{C}_{41}\text{H}_{51}\text{N}_3\text{O}_{11}\text{S}$ : 793.3. Found ( $\text{M}+\text{H}^+$ ): 794.9.



Compound 13f (using 4 equiv. of  $\text{CH}_3(\text{CH}_2)_{14}\text{CO}_2\text{H}$  as the acid, 6 equiv. of DMAP and 6 equiv. of EDC·HCl):  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.68 (s, 1H), 6.04 (dd, 2H), 5.17 (dd, 2H), 5.02-4.98 (m, 2H), 4.56 (bp, 1H), 4.34 (d, 1H), 4.28 (s, 1H), 4.19 (d, 1H), 4.12 (dd, 1H), 3.78 (s, 3H), 3.57 (s, 3H), 3.46 (d, 1H), 3.45-3.41 (m, 1H), 2.89-2.87 (m, 2H), 2.37-1.96 (m, 4H), 2.30 (s, 3H), 2.26 (s, 3H), 2.17 (s, 3H), 2.04 (s, 3H), 1.63-1.58 (m, 2H), 1.35-1.23 (m, 24H), 0.88 (t, 3H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  172.6, 168.6, 167.1, 148.9, 148.2, 145.8, 141.1, 140.6, 130.7, 125.3, 125.1, 124.7, 120.9, 118.1, 113.6, 113.1, 102.0, 99.2, 71.4, 61.5, 60.0, 59.8, 59.2, 58.6, 57.4, 55.0, 54.6, 41.6, 41.5, 33.9, 31.9, 31.7, 30.9, 29.7, 29.5, 29.3, 29.3, 29.2, 29.1, 24.7, 23.9, 22.7, 20.2, 15.9, 14.1, 9.6.

### Example 3

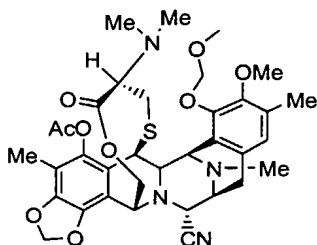
**Method C:** To a solution of 1 equiv. of 1 coevaporated twice with anhydrous toluene in  $\text{CH}_2\text{Cl}_2$  (0.05M) under Argon, were added 1.05 equiv. of phthalic anhydride. After 30 min the reaction was cold to  $0^\circ\text{C}$  and 2.5 equiv. of  $\text{Et}_3\text{N}$  and 1.5 equiv. of  $\text{ClCO}_2\text{Et}$  were added. 5 min later the reaction was warmed to RT and stirred for 7h. Then it was diluted with  $\text{CH}_2\text{Cl}_2$ , washed with a saturated solution of  $\text{NaHCO}_3$  and the organic layer dried with  $\text{Na}_2\text{SO}_4$ . Flash chromatography (hex/EtOAc, 3:2) gives 2d in 85% yield.



Compound 2j:  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.91-7.70 (m, 4H), 6.67 (s, 1H), 6.06 (dd, 2H), 5.19 (dd, 2H), 5.05 (d, 1H), 4.64-4.62 (m, 2H), 4.37 (d, 1H), 4.32 (s, 1H), 4.20 (d, 1H), 4.12 (dd, 1H), 3.79 (s, 3H), 3.58 (s, 3H), 3.50 (d, 1H), 3.41-3.40 (m, 1H), 2.85-2.83 (m, 2H), 2.36-2.11 (m, 2H), 2.33 (s, 3H), 2.31 (s, 3H), 2.14 (s, 3H), 2.05 (s, 3H); ESI-MS  $m/z$ : Calcd. for  $\text{C}_{41}\text{H}_{40}\text{N}_4\text{O}_{11}\text{S}$ : 796.2. Found ( $\text{M}+\text{H}^+$ ): 797.2.

## Example 4

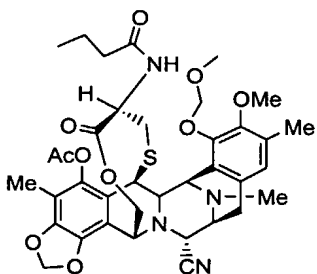
**Method D:** To a solution of 1 equiv. of **1** in CH<sub>3</sub>CN/CH<sub>2</sub>Cl<sub>2</sub> 3:1 (0.025M) under Argon, were added 1 equiv. of formaline solution (37%) and 1 equiv. of NaBH<sub>3</sub>CN. The solution was stirred at room temperature for 30 min. Then, 2 equiv. of acetic acid were added the solution which turned to orange-yellow was stirred for 1h 30 min. After this time the reaction mixture was diluted with CH<sub>2</sub>Cl<sub>2</sub>, neutralized with NaHCO<sub>3</sub> and extracted with CH<sub>2</sub>Cl<sub>2</sub>. The organic layer was dried with Na<sub>2</sub>SO<sub>4</sub>. Flash chromatography gives the pure compound.



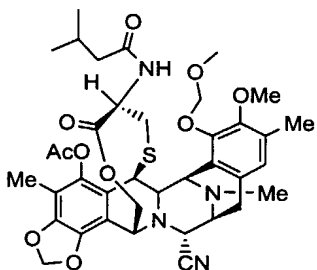
**Compound 2m:** <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 6.66 (s, 1H), 6.03 (dd, 2H), 5.17 (dd, 2H), 4.98 (d, 1H), 4.58 (bp, 1H), 4.32 (d, 1H), 4.25 (s, 1H), 4.15-4.13 (m, 1H), 3.95 (dd, 1H), 3.78 (s, 3H), 3.56 (s, 3H), 3.54-3.41 (m, 3H), 2.92-2.80 (m, 2H), 2.33 (s, 3H), 2.17 (s, 3H), 2.17-2.07 (bp, 6H), 2.16 (s, 3H), 2.04 (s, 3H), 1.86 (dd, 2H); ESI-MS m/z: Calcd. for C<sub>35</sub>H<sub>42</sub>N<sub>4</sub>O<sub>9</sub>S: 694.3. Found (M+H<sup>+</sup>): 695.3.

## Example 5

**Method E:** To a solution of 1 equiv. of **1** (**3p** for **3q-r**, **3s** for **3u**, **3v** for **3x**, **11** for **13c**, **13h**, **13l** and **24** for **26**) in CH<sub>2</sub>Cl<sub>2</sub> (0.08M) under Argon at RT were added 1.1 equiv. of pyridine. Then the reaction was cold to 0°C and 1.1 equiv of the acid chloride were added. 5 min later the reaction was warmed to RT and stirred for 45 min. Then it was diluted with CH<sub>2</sub>Cl<sub>2</sub>, washed with a saturated solution of NaCl and the organic layer dried with Na<sub>2</sub>SO<sub>4</sub>. Flash chromatography gives pure compounds.

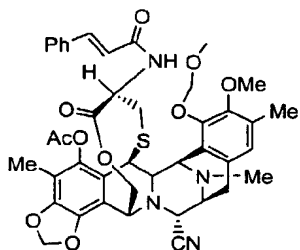


**Compound 2c** (using butyryl chloride): <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 6.76 (s, 1H), 6.04 (dd, 2H), 5.52 (bd, 1H), 5.17 (dd, 2H), 5.02 (d, 1H), 4.61 (ddd, 1H), 4.52 (bp, 1H), 4.34 (dd, 1H), 4.27 (s, 1H), 4.19 (d, 1H), 4.17 (dd, 1H), 3.75 (s, 3H), 3.56 (s, 3H), 3.47-3.43 (m, 2H), 2.92 (bd, 2H), 2.34-1.98 (m, 4H), 2.28 (s, 3H), 2.27 (s, 3H), 2.16 (s, 3H), 2.02 (s, 3H), 1.71-1.58 (m, 2H), 0.96 (t, 3H); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 171.7, 170.6, 168.4, 149.6, 148.5, 145.8, 141.0, 140.4, 131.0, 130.5, 125.7, 124.6, 120.4, 117.9, 113.4, 102.0, 99.1, 61.5, 60.1, 59.6, 59.2, 58.6, 57.4, 55.0, 54.5, 51.9, 41.8, 41.3, 38.2, 32.7, 23.7, 20.2, 18.8, 16.1, 13.7, 9.5. ESI-MS m/z: Calcd. for C<sub>37</sub>H<sub>44</sub>N<sub>4</sub>O<sub>10</sub>S: 736.3. Found (M+H<sup>+</sup>): 737.2.

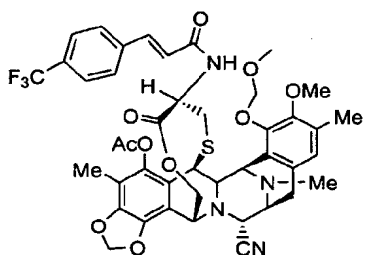


**Compound 2d** (using isovaleryl chloride): <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 6.76 (s, 1H), 6.05 (dd, 2H), 5.50 (bd, 1H), 5.17 (dd, 2H), 5.02 (d, 1H), 4.63 (ddd, 1H), 4.53 (bp, 1H), 4.35 (dd, 1H), 4.28 (s, 1H), 4.20 (d, 1H), 4.18 (dd, 1H), 3.76 (s, 3H), 3.56 (s, 3H), 3.47-3.43 (m, 2H), 2.92 (bd, 2H), 2.30-1.92 (m, 5H), 2.30 (s, 3H), 2.28 (s, 3H), 2.17 (s, 3H), 2.03 (s, 3H), 0.99 (d, 3H), 0.93 (d, 3H); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 171.3, 170.6, 168.4, 149.6, 148.5, 141.0, 140.5, 130.9,

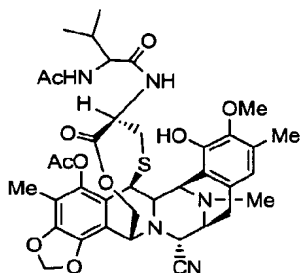
130.5, 125.7, 124.6, 120.4, 118.0, 113.5, 113.4, 102.0, 99.2, 61.5, 60.1, 59.6, 59.3, 58.6, 57.5, 55.0, 54.6, 51.8, 45.6, 41.9, 41.4, 31.8, 25.8, 23.8, 22.5, 22.4, 20.2, 16.3, 9.6. ESI-MS  $m/z$ : Calcd. for  $C_{38}H_{46}N_4O_{10}S$ : 750.3. Found ( $M+H^+$ ): 751.3.



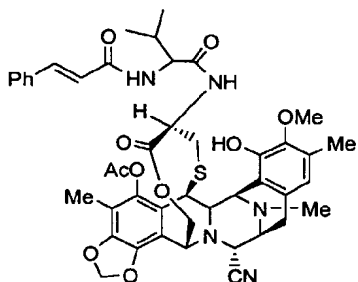
Compound **2h** (using cinnamoyl chloride):  $^1H$  NMR (300 MHz,  $CDCl_3$ ):  $\delta$  7.61 (d, 1H), 7.55-7.51 (m, 2H), 7.44-7.37 (m, 3H), 6.85 (s, 1H), 6.24 (d, 1H), 6.05 (dd, 2H), 5.72 (d, 1H), 5.16 (dd, 2H), 5.05 (d, 1H), 4.71 (ddd, 1H), 4.54 (bp, 1H), 4.35 (dd, 1H), 4.29 (s, 1H), 4.22-4.17 (m, 2H), 3.68 (s, 3H), 3.56 (s, 3H), 3.48-3.44 (m, 2H), 2.97-2.95 (m, 2H), 2.51-2.45 (m, 1H), 2.27-2.03 (m, 1H), 2.27 (s, 6H), 2.19 (s, 3H), 2.03 (s, 3H);  $^{13}C$  NMR (75 MHz,  $CDCl_3$ ):  $\delta$  170.5, 168.4, 164.5, 149.7, 148.5, 145.8, 142.1, 141.0, 140.4, 134.7, 131.1, 130.5, 129.8, 128.8, 127.9, 125.5, 124.4, 120.4, 119.7, 118.0, 113.4, 113.3, 102.0, 99.1, 61.4, 60.3, 59.6, 59.2, 58.8, 57.4, 54.9, 54.5, 52.6, 41.7, 41.4, 32.7, 23.8, 20.2, 16.3, 9.6. ESI-MS  $m/z$ : Calcd. for  $C_{42}H_{44}N_4O_{10}S$ : 796.3. Found ( $M+H^+$ ): 797.2.



Compound **2i** (using trans-3-(trifluoromethyl)-cinnamoyl chloride):  $^1H$  NMR (300 MHz,  $CDCl_3$ ):  $\delta$  7.82-7.51 (m, 5H), 6.85 (s, 1H), 6.29 (d, 1H), 6.05 (dd, 2H), 5.75 (d, 1H), 5.17 (dd, 2H), 5.05 (d, 1H), 4.73-4.69 (m, 1H), 4.55 (bp, 1H), 4.36 (d, 1H), 4.39 (s, 1H), 4.23-4.18 (m, 2H), 3.69 (s, 3H), 3.57 (s, 3H), 3.48-3.44 (m, 2H), 2.96 (bd, 2H), 2.49-2.44 (m, 1H), 2.27-2.04 (m, 1H), 2.27 (s, 6H), 2.19 (s, 3H), 2.04 (s, 3H);  $^{13}C$  NMR (75 MHz,  $CDCl_3$ ):  $\delta$  170.3, 168.4, 163.8, 149.7, 148.5, 145.9, 141.1, 140.5, 135.5, 134.6, 131.6, 131.0, 130.6, 129.5, 126.3, 126.2, 125.6, 124.4, 123.7, 123.6, 121.5, 120.3, 117.9, 113.5, 113.3, 102.0, 99.2, 61.4, 60.4, 59.6, 59.2, 58.9, 57.5, 54.9, 54.5, 52.6, 41.8, 41.4, 32.6, 23.8, 20.3, 16.2, 9.6. ESI-MS  $m/z$ : Calcd. for  $C_{43}H_{43}N_4F_3O_{10}S$ : 864.3. Found ( $M+H^+$ ): 865.0.

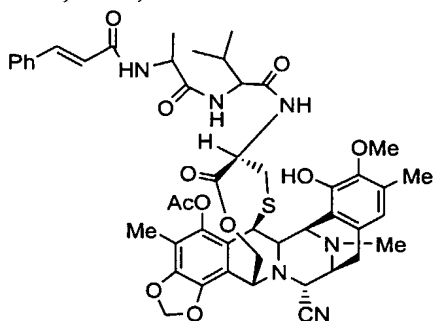


Compound **3q** (from Compound **3p** using acetyl chloride):  $^1H$  NMR (300 MHz,  $CDCl_3$ ):  $\delta$  6.54 (s, 1H), 6.08 (d, 1H), 6.05 (dd, 2H), 5.81 (s, 1H), 5.59 (d, 1H), 5.02 (d, 1H), 4.67 (dt, 1H), 4.58 (bp, 1H), 4.29 (s, 1H), 4.26 (dd, 1H), 4.21-4.16 (m, 1H), 4.09 (dd, 1H), 3.80 (s, 3H), 3.45-3.42 (m, 2H), 2.91-2.88 (m, 2H), 2.49 (s, 3H), 2.29-1.98 (m, 3H), 2.29 (s, 3H), 2.16 (s, 3H), 2.03 (s, 3H), 1.98 (s, 3H), 1.06 (d, 3H), 0.96 (d, 3H);  $^{13}C$  NMR (75 MHz,  $CDCl_3$ ):  $\delta$  170.2, 169.5, 168.6, 148.1, 145.9, 143.3, 141.1, 140.4, 130.4, 130.1, 120.4, 120.2, 118.5, 118.0, 113.5, 102.0, 61.4, 60.4, 59.3, 58.8, 57.7, 54.7, 54.6, 51.8, 42.0, 41.5, 32.7, 32.3, 23.8, 23.3, 20.5, 19.1, 18.0, 16.2, 9.6. ESI-MS  $m/z$ : Calcd. for  $C_{38}H_{45}N_5O_{10}S$ : 763.3. Found ( $M+H^+$ ): 764.3.



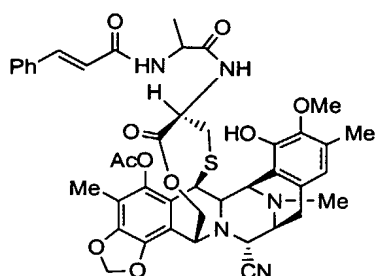
Compound **3r** (from Compound **3p** using cinnamoyl chloride):  $^1H$  NMR (300 MHz,  $CDCl_3$ ):  $\delta$  7.59 (d, 1H), 7.50-7.46 (m, 2H), 7.37-7.34 (m, 3H), 6.57 (s, 1H), 6.42 (d, 1H), 6.30 (d, 1H), 6.05 (dd, 2H), 5.81 (s, 1H), 5.64 (d,

1H), 5.03 (d, 1H), 4.70-4.67 (m, 1H), 4.58 (bp, 1H), 4.30-4.24 (m, 3H), 4.21-4.17 (m, 2H), 3.82 (s, 3H), 3.45 (bd, 2H), 2.92-2.89 (m, 2H), 2.56 (s, 3H), 2.28-2.03 (m, 3H), 2.28 (s, 3H), 2.17 (s, 3H), 2.03 (s, 3H), 1.10 (d, 3H), 1.00 (d, 3H); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 170.2, 170.1, **169.4**, 168.5, 165.3, 148.1, 145.9, 143.4, 141.2, 140.4, 134.8, 130.5, 130.1, 129.7, 128.8, 127.8, 120.6, 120.4, 120.2, 118.5, 118.0, 113.5, 113.5, 102.0, 61.4, 60.4, 59.4, 58.9, 57.7, 54.7, 54.6, 51.9, 42.0, 41.5, 32.7, 23.8, 20.5, 19.2, 18.0, 16.4, 9.6. ESI-MS m/z: Calcd. for C<sub>45</sub>H<sub>49</sub>N<sub>5</sub>O<sub>10</sub>S: 851.3. Found (M+H<sup>+</sup>): 852.3

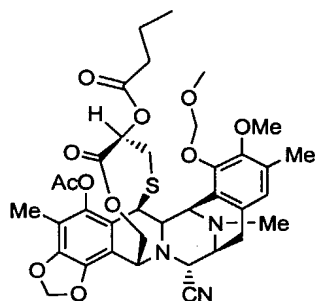


Compound **3u** (from Compound **3s** using cinnamoyl chloride): <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 7.63 (d, 1H), 7.50-7.47 (m, 2H), 7.38-7.35 (m, 3H), 6.62 (d, 1H), 6.55 (s, 1H), 6.41 (d, 1H), 6.35 (d, 1H), 6.05 (dd, 2H), 5.82 (s, 1H), 5.60 (d, 1H), 5.02 (d, 1H), 4.68-4.60 (m, 2H), 4.58 (bp, 1H), 4.29 (s, 1H), 4.26 (dd, 1H), 4.21-4.15 (m, 2H), 4.10 (dd, 1H), 3.79 (s, 3H), 3.45-3.43 (m, 2H), 2.91-2.88 (m, 2H), 2.48 (s, 3H), 2.30-2.03 (m, 3H), 2.28 (s, 3H), 2.16 (s, 3H),

2.03 (s, 3H), 1.41 (d, 3H), 1.04 (d, 3H), 0.94 (d, 3H); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 171.8, 170.2, 169.6, 168.5, 165.4, 148.0, 145.9, 143.3, 141.6, 141.1, 140.5, 134.7, 130.6, 129.8, 129.8, 128.8, 127.8, 120.3, 120.1, 118.7, 118.0, 113.5, 102.0, 61.5, 60.3, 59.4, 58.8, 57.8, 54.7, 54.6, 51.9, 49.0, 42.1, 41.5, 32.6, 32.3, 23.8, 20.5, 19.2, 18.6, 17.7, 16.3, 9.6. ESI-MS m/z: Calcd. for C<sub>48</sub>H<sub>54</sub>N<sub>6</sub>O<sub>11</sub>S: 922.4. Found (M+H<sup>+</sup>): 923.1.

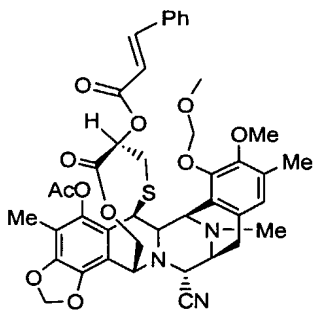


Compound **3x** (from Compound **3v** using cinnamoyl chloride): <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 7.60 (d, 1H), 7.49-7.46 (m, 2H), 7.37-7.34 (m, 3H), 6.59 (s, 1H), 6.48 (d, 1H), 6.39 (d, 1H), 6.05 (dd, 2H), 5.84 (s, 1H), 5.58 (d, 1H), 5.03 (d, 1H), 4.64-4.59 (m, 1H), 4.58 (bp, 1H), 4.36-4.8 (m, 1H), 4.28 (s, 1H), 4.26 (d, 1H), 4.22-4.17 (m, 2H), 3.81 (s, 3H), 3.45-3.43 (m, 2H), 2.92 (d, 2H), 2.53 (s, 3H), 2.28-2.03 (m, 2H), 2.28 (s, 3H), 2.16 (s, 3H), 2.03 (s, 3H), 1.54 (d, 3H); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 171.4, 170.1, 168.6, 164.9, 148.2, 145.9, 143.2, 141.1, 134.8, 130.5, 130.0, 129.7, 128.8, 127.8, 120.4, 120.4, 120.0, 118.8, 118.0, 113.6, 113.4, 102.0, 61.4, 60.6, 60.4, 59.3, 59.1, 54.8, 54.6, 51.7, 48.7, 41.9, 41.5, 32.5, 23.8, 20.5, 20.0, 16.2, 9.6. ESI-MS m/z: Calcd. for C<sub>43</sub>H<sub>45</sub>N<sub>5</sub>O<sub>10</sub>S: 823.3. Found (M+H<sup>+</sup>): 824.3.

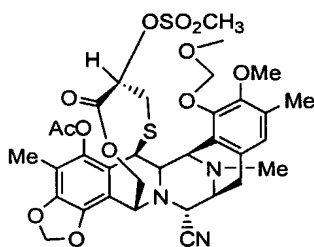


Compound **13c** (from Compound **11** using 20 equiv. of butyryl chloride and 30 equiv. of pyr): <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 6.68 (s, 1H), 6.04 (dd, 2H), 5.17 (dd, 2H), 5.02 (bt, 1H), 5.01 (d, 1H), 4.57 (bp, 1H), 4.34 (dd, 1H), 4.29 (s, 1H), 4.19 (d, 1H), 4.12 (dd, 1H), 3.78 (s, 3H), 3.56 (s, 3H), 3.46 (d, 1H), 3.45-3.42 (m, 1H), 2.88 (bd, 2H), 2.30-2.16 (m, 3H), 2.30 (s, 3H), 2.26 (s, 3H), 2.16 (s, 3H), 2.03 (s, 3H), 2.02-1.96 (m, 1H), 1.68-1.56 (m, 2H), 0.98 (t, 3H); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 172.5, 168.8, 167.3, 149.1, 148.4, 146.0, 141.3,

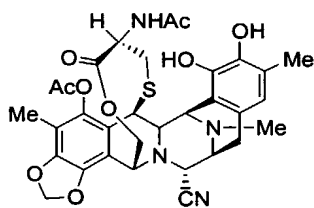
140.9, 131.0, 125.6, 125.0, 121.2, 118.3, 113.8, 113.3, 102.2, 99.4, 71.7, 61.7, 60.3, 60.0, 59.4, 58.8, 57.6, 55.2, 54.9, 41.9, 41.7, 36.1, 32.0, 24.2, 20.5, 18.5, 16.1, 13.9, 9.8. ESI-MS  $m/z$ : Calcd. for  $C_{37}H_{43}N_3O_{11}S$ : 737.3. Found ( $M+Na^+$ ): 760.2.



Compound **13h** (from Compound **11** using 5 equiv. of cinnamoyl chloride, 7.5 equiv. of pyr and  $CH_3CN$  as cosolvent):  $^1H$  NMR (300 MHz,  $CDCl_3$ ):  $\delta$  7.68 (d, 1H), 7.56-7.53 (m, 2H), 7.43-7.39 (m, 3H), 6.72 (s, 1H), 6.30 (d, 1H), 6.05 (dd, 2H), 5.22-5.13 (m, 3H), 5.04 (d, 1H), 4.58 (bp, 1H), 4.35 (d, 1H), 4.31 (s, 1H), 4.21 (d, 1H), 4.15 (dd, 1H), 3.79 (s, 3H), 3.57 (s, 3H), 3.48 (d, 1H), 3.43-3.39 (m, 1H), 2.90-2.88 (m, 2H), 2.47-2.41 (m, 1H), 2.31 (s, 3H), 2.24 (s, 3H), 2.17 (s, 3H), 2.07-2.03 (m, 1H), 2.04 (s, 3H);  $^{13}C$  NMR (75 MHz,  $CDCl_3$ ):  $\delta$  168.6, 167.1, 165.6, 148.8, 148.2, 145.7, 141.1, 140.6, 134.4, 130.9, 130.7, 130.4, 128.9, 128.2, 128.1, 125.2, 124.7, 120.9, 118.1, 117.3, 113.7, 113.1, 102.0, 99.2, 71.9, 61.5, 60.0, 59.8, 59.3, 58.5, 57.4, 54.9, 54.6, 41.7, 41.5, 31.8, 23.9, 20.2, 16.0, 9.6. ESI-MS  $m/z$ : Calcd. for  $C_{42}H_{43}N_3O_{11}S$ : 797.3. Found ( $M+H^+$ ): 798.8.



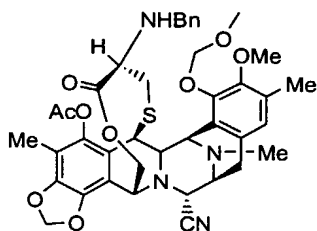
Compound **13II** (from Compound **11** using 5 equiv. of methanesulfonyl chloride and 5 equiv. of  $Et_3N$  as base):  $^1H$  NMR (300 MHz,  $CDCl_3$ ):  $\delta$  6.65 (s, 1H), 6.04 (dd, 2H), 5.17 (dd, 2H), 5.00 (d, 1H), 4.93 (dd, 1H), 4.58 (bp, 1H), 4.34 (dd, 1H), 4.29 (s, 1H), 4.16-4.12 (m, 2H), 3.77 (s, 3H), 3.56 (s, 3H), 3.46 (d, 1H), 3.44-3.39 (m, 1H), 3.11 (s, 3H), 2.96-2.81 (m, 2H), 2.50-2.42 (m, 1H), 2.30 (s, 3H), 2.26 (s, 3H), 2.18 (s, 3H), 2.04-1.97 (m, 1H), 2.03 (s, 3H); ESI-MS  $m/z$ : Calcd. for  $C_{34}H_{39}N_3O_{12}S_2$ : 745.2. Found ( $M+H^+$ ): 746.2.



Compound **26** (from Compound **24** using 1.05 equiv of acetyl chloride and without base):  $^1H$  NMR (300 MHz,  $CDCl_3$ ):  $\delta$  6.51 (s, 1H), 6.05 (d, 2H), 5.95 (s, 1H), 5.60 (d, 1H), 5.59 (bp, 1H), 5.03 (d, 1H), 4.58-4.53 (m, 2H), 4.27 (s, 1H), 4.26 (d, 1H), 4.20-4.16 (m, 2H), 3.43-3.42 (m, 2H), 2.90-2.88 (m, 2H), 2.27-2.11 (m, 2H), 2.27 (s, 3H), 2.24 (s, 3H), 2.14 (s, 3H), 2.03 (s, 3H), 1.85 (s, 3H);  $^{13}C$  NMR (75 MHz,  $CDCl_3$ ):  $\delta$  170.4, 169.5, 168.9, 145.8, 144.5, 140.9, 140.4, 139.9, 127.1, 123.6, 120.1, 119.8, 119.2, 118.1, 113.5, 113.4, 102.0, 61.3, 60.4, 59.2, 58.9, 54.7, 54.5, 52.0, 41.7, 41.4, 32.3, 23.5, 22.8, 20.6, 16.2, 9.6; ESI-MS  $m/z$ : Calcd. for  $C_{32}H_{34}N_4O_9S$ : 650.2. Found ( $M+H^+$ ): 651.3.

#### Example 6

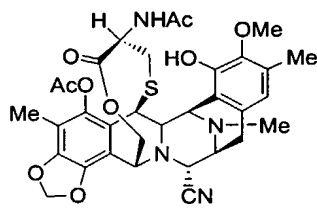
**Method F:** To a solution of 1 equiv. of **1** in DMF (0.03M) under Argon at room temperature, were added 0.9 equiv. of  $CS_2CO_3$  and 0.9 equiv on BnBr. After 2h 30 min the reaction was quenched with 1 $\mu$ L of AcOH, diluted with Hex/EtOAc (1:3), washed with  $H_2O$  and extracted with Hex/EtOAc (1:3). The organic layer was dried with  $Na_2SO_4$ . Flash chromatography give pure compound **2n**.



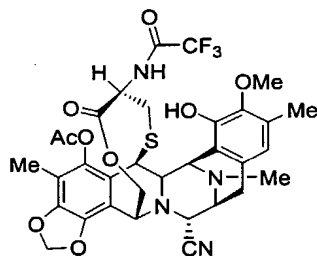
**Compound 2n:**  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.32-7.20 (m, 5H), 6.56 (s, 1H), 6.02 (dd, 2H), 5.15 (dd, 2H), 5.04 (d, 1H), 4.51 (bp, 1H), 4.32 (d, 1H), 4.25-4.23 (m, 2H), 4.12 (dd, 1H), 3.74 (s, 3H), 3.62 (dd, 2H), 3.56 (s, 3H), 3.44-3.40 (m, 2H), 3.38-3.20 (m, 1H), 3.19-2.84 (m, 2H), 2.36-1.91 (m, 2H), 2.29 (s, 3H), 2.19 (s, 3H), 2.03 (s, 3H), 1.91 (s, 3H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  172.7, 168.6, 149.3, 148.2, 145.6, 140.9, 140.4, 139.9, 131.5, 130.3, 128.3, 128.1, 126.9, 124.9, 124.7, 120.9, 118.1, 113.8, 113.2, 101.9, 99.1, 61.5, 59.7, 59.6, 59.5, 59.2, 58.9, 57.4, 54.9, 54.7, 51.3, 41.5, 41.4, 33.3, 23.8, 20.3, 15.3, 9.6. ESI-MS  $m/z$ : Calcd. for  $\text{C}_{40}\text{H}_{44}\text{N}_4\text{O}_9\text{S}$ : 756.3. Found ( $\text{M}+\text{Na}^+$ ): 779.2.

### Example 7

**Method G:** To a solution of 1 equiv. of **2a-n**, **2t**, **2w**, **2y**, **11**, **12\***, **13a-c**, **13e-f**, **13h**, **13ll**, **14a\*** or **7-9** in  $\text{CH}_3\text{CN}/\text{CH}_2\text{Cl}_2$  5:4 (0.026M) under Argon were added 6 equiv. of NaI and 6 equiv. of fresh distilled  $\text{TMSCl}$ . After 20 min the reaction was quenched with a saturated solution of  $\text{Na}_2\text{S}_2\text{O}_4$ , diluted with  $\text{CH}_2\text{Cl}_2$ , washed with  $\text{Na}_2\text{S}_2\text{O}_4$  (x3), or with NaCl. The aqueous layer extracted with  $\text{CH}_2\text{Cl}_2$ . The organic layer was dried with  $\text{Na}_2\text{SO}_4$ . Flash chromatography gives pure compounds **3a-n**, **3p**, **3s-t**, **3v-w**, **3y-z**, **15**, **16\***, **17a-c**, **17e-f**, **17h**, **17ll**, **18a\***.

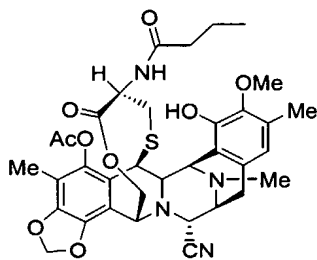


**Compound 3a (from 2a):**  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.56 (s, 1H), 6.04 (dd, 2H), 5.78 (s, 1H), 5.52 (bd, 1H), 5.02 (d, 1H), 4.58 (ddd, 1H), 4.53 (bs, 1H), 4.27-4.25 (m, 2H), 4.19-4.15 (m, 2H), 3.77 (s, 3H), 3.44-3.43 (m, 2H), 2.92-2.90 (m, 2H), 2.36-2.02 (m, 2H), 2.36 (s, 3H), 2.30 (s, 3H), 2.16 (s, 3H), 2.02 (s, 3H), 1.88 (s, 3H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  170.5, 168.8, 168.4, 148.1, 145.8, 143.1, 141.0, 140.3, 130.7, 129.9, 129.0, 120.3, 119.0, 117.9, 113.5, 102.0, 61.3, 60.3, 60.2, 59.3, 58.9, 54.7, 54.5, 51.9, 41.8, 41.4, 32.4, 23.7, 22.8, 20.4, 16.0, 9.5; ESI-MS  $m/z$ : Calcd. for  $\text{C}_{33}\text{H}_{36}\text{N}_4\text{O}_9\text{S}$ : 664.2. Found ( $\text{M}+\text{H}^+$ ): 665.2.



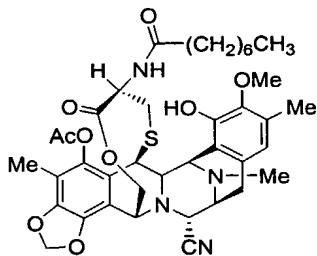
**Compound 3b (from 2b):**  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.52 (s, 1H), 6.41 (bd, 1H), 6.05 (dd, 2H), 5.72 (s, 1H), 5.05 (d, 1H), 4.60 (bp, 1H), 4.54-4.51 (m, 1H), 4.32 (s, 1H), 4.26-4.18 (m, 3H), 3.74 (s, 3H), 3.46-3.42 (m, 2H), 2.97-2.80 (m, 2H), 2.44-2.38 (m, 1H), 2.30-2.03 (m, 1H), 2.30 (s, 3H), 2.27 (s, 3H), 2.15 (s, 3H), 2.03 (s, 3H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  168.8, 168.5, 156.3, 155.8, 155.3, 147.6, 146.0, 143.1, 141.2, 140.5, 130.5, 129.9, 120.7, 120.6, 120.1, 118.0, 117.9, 113.2, 101.1, 61.4, 60.7, 60.1, 59.5, 58.9, 54.6, 54.5, 52.8, 42.0, 41.5, 31.9, 23.8, 20.4, 15.6, 9.6; ESI-MS  $m/z$ : Calcd. for  $\text{C}_{33}\text{H}_{33}\text{F}_3\text{N}_4\text{O}_9\text{S}$ : 718.2. Found ( $\text{M}+\text{H}^+$ ): 719.2.



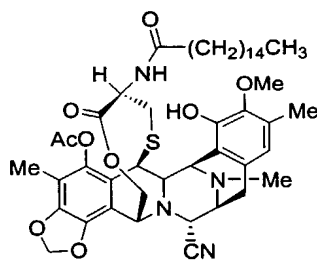


Compound **3c** (from **2c**):  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.54 (s, 1H), 6.03 (dd, 2H), 5.82 (s, 1H), 5.49 (bd, 1H), 5.02 (d, 1H), 4.61 (ddd, 1H), 4.53 (bp, 1H), 4.27-4.24 (m, 2H), 4.19-4.15 (m, 2H), 3.76 (s, 3H), 3.44-3.41 (m, 2H), 2.90 (bd, 2H), 2.31-1.94 (m, 4H), 2.31 (s, 3H), 2.28 (s, 3H), 2.15 (s, 3H), 2.02 (s, 3H), 1.67-1.57 (m, 2H), 0.95 (t, 3H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  171.8, 170.5, 148.0, 145.8, 143.1, 141.0, 140.4, 130.8, 129.0, 120.4, 120.2, 119.0, 118.0, 113.4, 102.0, 61.4, 60.2, 59.4, 58.9, 54.7, 54.5, 51.7, 41.8, 41.4, 38.2, 32.6, 23.8, 20.5, 18.8, 16.0, 13.7, 9.6. ESI-MS  $m/z$ : Calcd. for  $\text{C}_{35}\text{H}_{40}\text{N}_4\text{O}_9\text{S}$ : 692.2. Found ( $\text{M}+\text{H}^+$ ): 693.9.

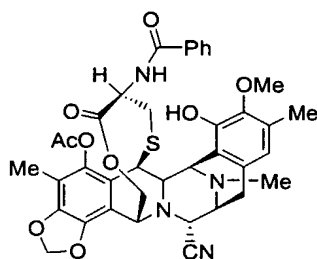
Compound **3d** (from **2d**):  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.54 (s, 1H), 6.04 (dd, 2H), 5.76 (s, 1H), 5.48 (bd, 1H), 5.02 (d, 1H), 4.66-4.60 (m, 1H), 4.53 (bp, 1H), 4.27-4.23 (m, 2H), 4.19-4.15 (m, 2H), 3.76 (s, 3H), 3.44-3.42 (m, 2H), 2.90 (bd, 2H), 2.33-1.90 (m, 5H), 2.33 (s, 3H), 2.28 (s, 3H), 2.15 (s, 3H), 2.02 (s, 3H), 0.98 (d, 3H), 0.92 (d, 3H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  171.3, 170.6, 168.5, 148.0, 145.8, 143.1, 141.1, 140.4, 130.8, 129.0, 127.6, 120.5, 120.3, 119.1, 118.0, 113.5, 102.0, 74.2, 61.4, 60.3, 59.4, 58.8, 54.7, 54.6, 51.7, 45.5, 41.9, 41.5, 32.7, 25.8, 23.8, 22.5, 22.4, 20.5, 16.2, 9.6. ESI-MS  $m/z$ : Calcd. for  $\text{C}_{36}\text{H}_{42}\text{N}_4\text{O}_9\text{S}$ : 706.3. Found ( $\text{M}+\text{Na}^+$ ): 729.2.



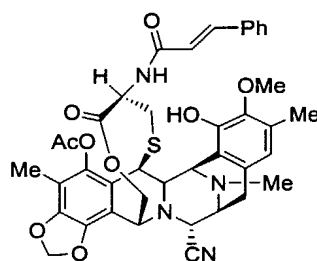
Compound **3e** (from **2e**):  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.54 (s, 1H), 6.04 (dd, 2H), 5.75 (s, 1H), 5.48 (bd, 1H), 5.02 (d, 1H), 4.60 (ddd, 1H), 4.53 (bp, 1H), 4.27-4.24 (m, 2H), 4.19-4.15 (m, 2H), 3.77 (s, 3H), 3.48-3.42 (m, 2H), 2.91 (bd, 2H), 2.32-1.97 (m, 4H), 2.32 (s, 3H), 2.28 (s, 3H), 2.16 (s, 3H), 2.02 (s, 3H), 1.62-1.41 (m, 2H), 1.390-1.25 (m, 8H), 0.89 (t, 3H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  172.0, 170.6, 168.4, 148.0, 145.8, 143.1, 141.0, 140.4, 130.8, 129.0, 120.4, 120.2, 119.0, 118.0, 113.7, 113.5, 102.0, 61.4, 60.3, 59.4, 58.9, 54.7, 54.6, 51.8, 41.8, 41.5, 36.3, 32.6, 31.7, 29.3, 29.1, 25.4, 23.8, 22.6, 20.5, 16.1, 14.0, 9.6; ESI-MS  $m/z$ : Calcd. for  $\text{C}_{39}\text{H}_{48}\text{N}_4\text{O}_9\text{S}$ : 748.3. Found ( $\text{M}+\text{H}^+$ ): 749.3.



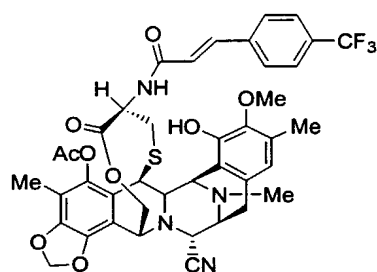
Compound **3f** (from **2f**):  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.55 (s, 1H), 6.04 (dd, 2H), 5.73 (s, 1H), 5.48 (bd, 1H), 5.02 (d, 1H), 4.60 (ddd, 1H), 4.56-4.50 (bp, 1H), 4.28-4.24 (m, 2H), 4.20-4.14 (m, 2H), 3.77 (s, 3H), 3.44-3.40 (m, 2H), 2.92-2.90 (bd, 2H), 2.35-1.95 (m, 4H), 2.32 (s, 3H), 2.29 (s, 3H), 2.16 (s, 3H), 2.03 (s, 3H), 1.62-1.58 (m, 2H), 1.38-1.20 (m, 24H), 0.88 (t, 3H); ESI-MS  $m/z$ : Calcd. for  $\text{C}_{47}\text{H}_{64}\text{N}_4\text{O}_9\text{S}$ : 860.4. Found ( $\text{M}+\text{H}^+$ ): 861.5.



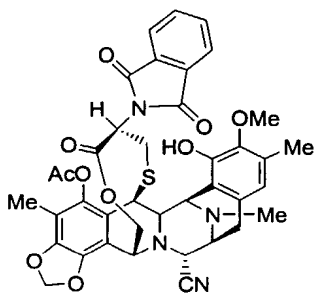
**Compound 3g** (from **2g**):  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.69-7.66 (m, 2H), 7.57-7.45 (m, 3H), 6.48 (s, 1H), 6.35 (d, 1H), 6.06 (dd, 2H), 5.70 (s, 1H), 5.07 (d, 1H), 4.78-4.74 (m, 1H), 4.58 (bp, 1H), 4.33 (s, 1H), 4.26-4.18 (m, 3H), 3.61 (s, 3H), 3.47-3.45 (m, 2H), 2.92 (bd, 2H), 2.60-2.53 (m, 1H), 2.28-1.93 (m, 1H), 2.28 (s, 3H), 2.14 (s, 3H), 2.04 (s, 3H), 1.93 (s, 3H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  171.7, 170.5, 166.4, 147.7, 145.9, 143.0, 141.1, 140.5, 134.2, 131.6, 130.8, 129.4, 128.6, 127.0, 120.4, 118.5, 118.0, 113.7, 113.4, 102.0, 61.5, 60.3, 60.1, 59.7, 58.8, 54.7, 53.1, 41.9, 41.5, 32.8, 23.9, 20.4, 15.6, 9.6; ESI-MS  $m/z$ : Calcd. for  $\text{C}_{38}\text{H}_{38}\text{N}_4\text{O}_9\text{S}$ : 726.2. Found ( $\text{M}+\text{H}^+$ ): 727.2.



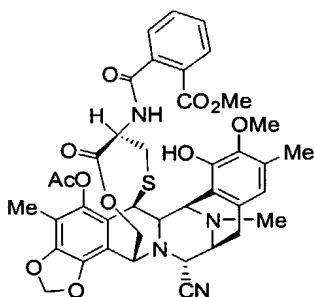
Compound **3h** (from **2h**):  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.60 (d, 1H), 7.54-7.51 (m, 2H), 7.44-7.38 (m, 3H), 6.63 (s, 1H), 6.22 (d, 1H), 6.05 (dd, 2H), 5.79 (s, 1H), 5.73 (d, 1H), 5.05 (d, 1H), 4.71 (ddd, 1H), 4.55 (bp, 1H), 4.29 (s, 1H), 4.26 (s, 1H), 4.21-4.17 (m, 2H), 3.68 (s, 3H), 3.48-3.42 (m, 2H), 2.95-2.93 (m, 2H), 2.49-2.44 (m, 1H), 2.29-2.03 (m, 1H), 2.29 (s, 3H), 2.27 (s, 3H), 2.17 (s, 3H), 2.03 (s, 3H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  170.4, 168.4, 164.5, 148.1, 145.8, 143.1, 142.0, 141.0, 140.4, 134.7, 130.8, 129.8, 129.2, 128.8, 127.9, 120.2, 119.8, 118.9, 118.0, 113.6, 113.3, 102.0, 61.4, 60.4, 60.2, 59.4, 59.0, 54.6, 54.6, 52.5, 41.8, 41.5, 32.6, 23.8, 20.5, 16.2, 9.6. ESI-MS  $m/z$ : Calcd. for  $\text{C}_{40}\text{H}_{40}\text{N}_4\text{O}_9\text{S}$ : 752.2. Found ( $\text{M}+\text{Na}^+$ ): 775.8.



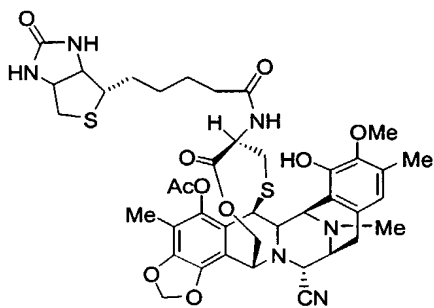
Compound **3i** (from **2i**):  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.82 (s, 1H), 7.66-7.51 (m, 4H), 6.64 (s, 1H), 6.26 (d, 1H), 6.05 (dd, 2H), 5.77 (s, 1H), 5.74 (d, 1H), 5.05 (d, 1H), 4.72 (ddd, 1H), 4.56 (bp, 1H), 4.29 (s, 1H), 4.26 (dd, 1H), 4.22-4.16 (m, 2H), 3.70 (s, 3H), 3.46-3.44 (m, 2H), 2.94 (bd, 2H), 2.47-2.40 (m, 1H), 2.30-2.03 (m, 1H), 2.30 (s, 3H), 2.28 (s, 3H), 2.17 (s, 3H), 2.03 (s, 3H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  170.3, 163.9, 148.1, 143.1, 141.1, 140.4, 135.6, 131.7, 130.9, 129.5, 129.0, 126.2, 123.6, 121.7, 120.3, 118.0, 113.3, 102.0, 99.2, 61.4, 60.5, 60.2, 59.4, 59.1, 54.7, 54.6, 52.5, 41.8, 41.5, 32.6, 23.8, 20.5, 16.2, 9.6. ESI-MS  $m/z$ : Calcd. for  $\text{C}_{41}\text{H}_{39}\text{N}_4\text{F}_3\text{O}_9\text{S}$ : 820.2. Found ( $\text{M}+\text{H}^+$ ): 821.3.



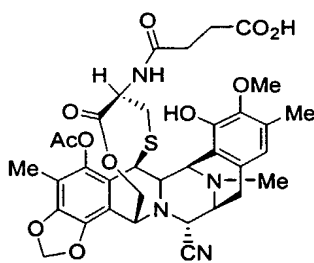
Compound **3j** (from **2j**):  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.77-7.68 (m, 4H), 6.26 (s, 1H), 6.06 (dd, 2H), 5.77 (s, 1H), 4.98 (d, 1H), 4.61-4.55 (m, 2H), 4.33-4.21 (m, 2H), 4.09 (d, 1H), 4.97 (dd, 1H), 3.97 (s, 3H), 3.47-3.31 (m, 2H), 2.93-2.77 (m, 2H), 2.36 (s, 3H), 2.33-2.14 (m, 2H), 2.23 (s, 3H), 2.17 (s, 3H), 2.05 (s, 3H); ESI-MS  $m/z$ : Calcd. for  $\text{C}_{39}\text{H}_{36}\text{N}_4\text{O}_{10}\text{S}$ : 752.2. Found ( $\text{M}+\text{H}^+$ ): 753.2.



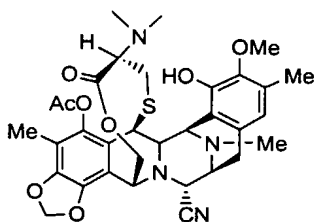
Compound **6**:  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.95 (dd, 1H), 7.66-7.45 (m, 3H), 6.13 (s, 1H), 6.07 (dd, 2H), 5.88 (d, 1H), 5.64 (s, 1H), 5.06 (d, 1H), 4.83-4.81 (m, 1H), 4.53 (bp, 1H), 4.30-4.17 (m, 4H), 3.79 (s, 3H), 3.61 (s, 3H), 3.45-3.40 (m, 2H), 2.94-2.85 (m, 2H), 2.29-2.04 (m, 2H), 2.29 (s, 3H), 2.14 (s, 3H), 2.04 (s, 6H); ESI-MS  $m/z$ : Calcd. for  $\text{C}_{40}\text{H}_{40}\text{N}_4\text{O}_{11}\text{S}$ : 784.2. Found ( $\text{M}+\text{H}^+$ ): 785.1.



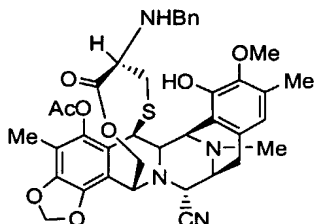
Compound **3k** (from **2k**):  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.78 (s, 1H), 6.55 (s, 1H), 6.45 (s, 1H), 6.04 (dd, 2H), 5.38 (bd, 1H), 5.29 (bs, 1H), 5.15 (d, 1H), 4.66 (m, 1H), 4.60 (bp, 1H), 4.55-4.51 (m, 1H), 4.40 (d, 1H), 4.34-4.29 (m, 2H), 4.25 (s, 1H), 4.14 (d, 1H), 3.79 (s, 3H), 3.43-3.39 (m, 2H), 3.09-3.05 (m, 1H), 2.96-2.90 (m, 3H), 2.70 (d, 1H), 2.34-1.94 (m, 4H), 2.34 (s, 3H), 2.30 (s, 3H), 2.11 (s, 3H), 2.02 (s, 3H), 1.81-1.25 (m, 6H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  171.5, 170.8, 168.7, 163.8, 148.8, 145.8, 142.8, 141.1, 140.3, 131.2, 128.9, 120.7, 120.3, 120.1, 118.3, 113.5, 102.0, 61.9, 61.2, 60.2, 59.8, 59.4, 59.4, 56.4, 55.1, 54.7, 51.3, 41.8, 41.4, 41.1, 34.5, 32.6, 27.8, 27.7, 25.0, 24.1, 20.7, 16.1, 9.6; ESI-MS  $m/z$ : Calcd. for  $\text{C}_{41}\text{H}_{48}\text{N}_6\text{O}_{10}\text{S}_2$ : 849.0. Found ( $\text{M}+\text{H}^+$ ): 850.0.



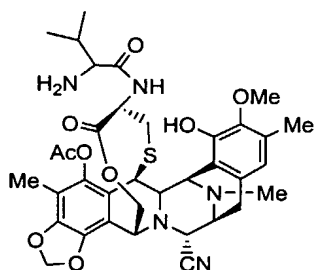
Compound **3l** (from **2l**):  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.57 (s, 1H), 6.04 (dd, 2H), 5.90 (bp, 1H), 5.63 (bd, 1H), 5.02 (d, 1H), 4.60-4.55 (m, 2H), 4.27-4.17 (m, 4H), 3.76 (s, 3H), 3.47-3.39 (m, 2H), 2.90 (bd, 2H), 2.68-2.61 (m, 2H), 2.58-2.02 (m, 4H), 2.32 (s, 3H), 2.29 (s, 3H), 2.16 (s, 3H), 2.02 (s, 3H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  176.4, 170.5, 170.2, 168.6, 148.1, 145.8, 143.1, 141.0, 140.3, 130.7, 129.2, 120.3, 120.0, 119.0, 118.0, 113.5, 113.3, 102.0, 61.3, 60.4, 60.3, 59.2, 58.9, 54.6, 54.4, 51.9, 41.8, 41.4, 32.3, 30.2, 29.6, 29.1, 28.3, 23.7, 20.5, 16.0, 9.6. ESI-MS  $m/z$ : Calcd. for  $\text{C}_{35}\text{H}_{38}\text{N}_4\text{O}_{11}\text{S}$ : 722.2. Found ( $\text{M}+\text{H}^+$ ): 723.2.



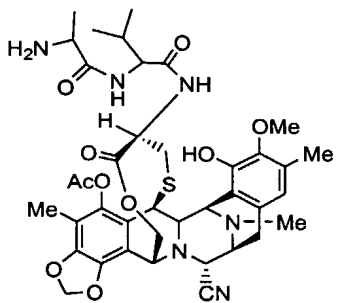
Compound **3m** (from **2m**):  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.45 (s, 1H), 6.02 (d, 2H), 5.67 (s, 1H), 4.98 (d, 1H), 4.55 (bp, 1H), 4.27-4.22 (m, 2H), 4.14 (d, 1H), 3.94 (dd, 1H), 3.78 (s, 3H), 3.65-3.38 (m, 3H), 2.96-2.79 (m, 2H), 2.44-2.02 (m, 7H), 2.34 (s, 3H), 2.20 (s, 3H), 2.16 (s, 3H), 2.03 (s, 3H), 1.88-1.82 (m, 1H); ESI-MS  $m/z$ : Calcd. for  $\text{C}_{33}\text{H}_{38}\text{N}_4\text{O}_8\text{S}$ : 650.2. Found ( $\text{M}+\text{H}^+$ ): 651.3.



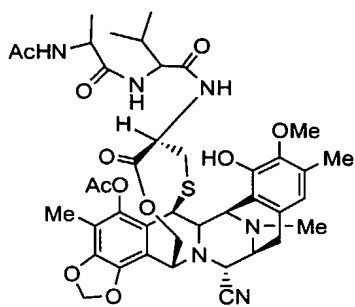
Compound **3n** (from **2n**):  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.31-7.21 (m, 5H), 6.37 (s, 1H), 6.02 (dd, 2H), 5.67 (s, 1H), 5.04 (d, 1H), 4.52 (bp, 1H), 4.24-4.22 (m, 3H), 4.11 (dd, 1H), 3.73 (s, 3H), 3.62 (dd, 2H), 3.42-3.41 (m, 2H), 3.19-3.18 (m, 1H), 3.03-2.83 (m, 2H), 2.34-2.30 (m, 1H), 2.30 (s, 3H), 2.18 (s, 3H), 2.05-2.02 (m, 1H), 2.02 (s, 3H), 1.93 (s, 3H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  172.7, 168.5, 147.7, 145.6, 142.9, 141.0, 140.4, 140.1, 130.6, 129.3, 128.2, 128.2, 126.8, 120.7, 118.2, 118.0, 113.8, 113.3, 101.9, 99.1, 61.5, 60.1, 59.6, 59.5, 59.2, 54.7, 51.3, 41.6, 41.5, 33.4, 23.8, 20.5, 15.3, 9.6. ESI-MS  $m/z$ : Calcd. for  $\text{C}_{38}\text{H}_{40}\text{N}_4\text{O}_8\text{S}$ : 712.3. Found ( $\text{M}+\text{H}^+$ ): 713.3.



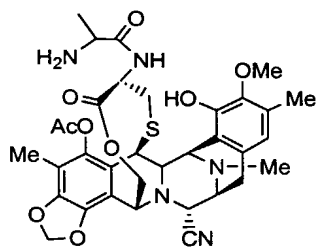
Compound **3p** (from **7**):  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.73 (bp, 1H), 6.51 (s, 1H), 6.05 (dd, 2H), 5.03 (d, 1H), 4.64 (dt, 1H), 4.55 (bp, 1H), 4.31 (s, 1H), 4.26 (dd, 1H), 4.21 (d, 1H), 4.17 (dd, 1H), 3.76 (s, 3H), 3.49-3.42 (m, 2H), 2.99 (d, 1H), 2.90-2.88 (m, 2H), 2.47-1.97 (m, 3H), 2.32 (s, 3H), 2.29 (s, 3H), 2.13 (s, 3H), 2.03 (s, 3H), 0.97 (d, 3H), 0.79 (d, 3H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  173.6, 170.4, 168.5, 147.6, 145.9, 143.1, 141.1, 140.5, 130.8, 129.0, 120.8, 120.6, 118.8, 118.0, 113.5, 113.3, 102.0, 61.5, 60.6, 60.2, 60.0, 59.6, 58.6, 54.7, 54.6, 51.9, 42.0, 41.5, 33.0, 31.6, 23.9, 20.4, 19.6, 16.8, 16.2, 9.6. ESI-MS  $m/z$ : Calcd. for  $\text{C}_{36}\text{H}_{43}\text{N}_5\text{O}_9\text{S}$ : 721.3. Found ( $\text{M}+\text{H}^+$ ): 722.2.



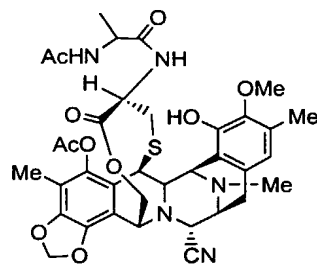
Compound **3s** (from **9** using 9 equiv of  $\text{TMSCl}$  and  $\text{NaI}$ . The reaction was quenched with brine and  $\text{Na}_2\text{CO}_3$ ):  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.74 (d, 1H), 6.55 (s, 1H), 6.05 (dd, 2H), 5.61 (d, 1H), 5.02 (d, 1H), 4.68-4.64 (m, 1H), 4.57 (bp, 1H), 4.29 (s, 1H), 4.27 (dd, 1H), 4.20-4.16 (m, 2H), 4.04 (dd, 1H), 3.79 (s, 3H), 3.52-3.43 (m, 3H), 2.91-2.89 (m, 2H), 2.49 (s, 3H), 2.29-2.02 (m, 3H), 2.29 (s, 3H), 2.16 (s, 3H), 2.02 (s, 3H), 1.33 (d, 3H), 1.07 (d, 3H), 0.97 (d, 3H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  175.2, 170.2, 170.2, 168.5, 148.0, 145.9, 143.3, 141.1, 140.4, 130.4, 130.1, 120.4, 120.2, 118.5, 118.0, 113.5, 102.0, 61.5, 60.4, 60.3, 59.4, 58.8, 57.4, 54.7, 54.6, 51.8, 50.9, 42.0, 41.5, 32.7, 32.2, 23.8, 21.8, 20.5, 19.3, 18.0, 16.3, 9.6. ESI-MS  $m/z$ : Calcd. for  $\text{C}_{39}\text{H}_{48}\text{N}_6\text{O}_{10}\text{S}$ : 792.3. Found ( $\text{M}+\text{H}^+$ ): 793.3.



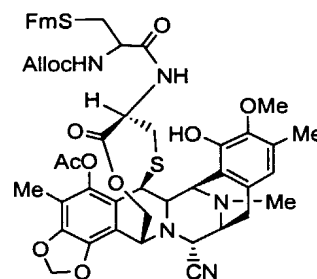
Compound **3t** (from **2t**):  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.59 (bd, 1H), 6.53 (s, 1H), 6.28-6.22 (m, 1H), 6.04 (dd, 2H), 5.89 (s, 1H), 5.60, 5.58 (2d, 1H), 5.01 (d, 1H), 4.66-4.62 (m, 1H), 4.57 (bp, 1H), 4.50-4.43 (m, 1H), 4.28 (s, 1H), 4.25 (d, 1H), 4.20-4.12 (m, 2H), 4.09-4.04 (m, 1H), 3.78, 3.77 (2s, 3H), 3.47-3.42 (m, 2H), 2.90-2.87 (m, 2H), 2.46 (s, 3H), 2.28-1.98 (m, 3H), 2.28 (s, 3H), 2.16, 2.15 (2s, 3H), 2.03, 2.02 (2s, 3H), 1.98 (s, 3H), 1.36, 1.32 (2d, 3H), 1.05, 1.03 (2d, 3H), 0.93 (d, 3H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  171.9, 170.1, 169.7, 169.6, 168.5, 148.0, 145.9, 143.2, 141.1, 140.4, 130.6, 129.8, 120.3, 120.2, 118.7, 118.0, 113.4, 102.0, 61.4, 60.3, 60.3, 59.4, 58.8, 57.7, 57.6, 54.6, 54.5, 51.9, 48.9, 48.9, 42.0, 41.5, 32.6, 32.3, 32.2, 23.8, 23.1, 20.5, 19.2, 19.1, 19.1, 18.5, 17.7, 17.7, 16.2, 9.6. ESI-MS  $m/z$ : Calcd. for  $\text{C}_{41}\text{H}_{50}\text{N}_6\text{O}_{11}\text{S}$ : 834.3. Found ( $\text{M}+\text{H}^+$ ): 835.3.



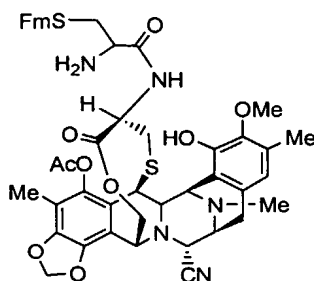
Compound **3v** (from **8**; the reaction was quenched with brine and  $\text{Na}_2\text{CO}_3$ ):  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.70 (bp, 1H), 6.52 (s, 1H), 6.04 (dd, 2H), 5.03 (d, 1H), 4.58-4.53 (m, 2H), 4.30 (s, 1H), 4.25 (dd, 1H), 4.20-4.14 (m, 2H), 3.76 (s, 3H), 3.45-3.42 (m, 2H), 3.30 (dd, 1H), 2.90-2.88 (m, 2H), 2.38-2.00 (m, 2H), 2.30 (s, 3H), 2.29 (s, 3H), 2.14 (s, 3H), 2.03 (s, 3H), 1.25 (d, 3H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  175.0, 170.3, 168.4, 147.6, 145.9, 143.1, 141.1, 140.5, 130.8, 129.0, 120.9, 120.5, 118.7, 118.0, 113.5, 113.3, 102.0, 61.5, 60.2, 60.1, 59.6, 58.8, 54.8, 54.6, 52.1, 50.8, 41.9, 41.5, 32.7, 23.9, 21.6, 20.4, 16.1, 9.6. ESI-MS  $m/z$ : Calcd. for  $\text{C}_{34}\text{H}_{39}\text{N}_5\text{O}_9\text{S}$ : 693.2. Found ( $\text{M}+\text{H}^+$ ): 694.3.



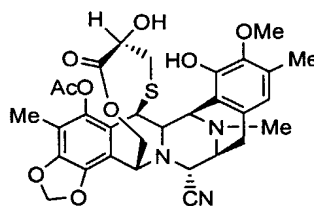
Compound **3w** (from **2w**; the reaction was quenched with brine):  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.67, 6.55 (2s, 1H), 6.30 (m, 1H), 6.05 (dd, 2H), 5.86, 5.79 (2s, 1H), 5.65, 5.54 (2bd, 1H), 5.03, 5.02 (2d, 1H), 4.60-4.17 (m, 7H), 3.79, 3.76 (2s, 3H), 3.45-3.40 (m, 2H), 2.92-2.85 (bd, 2H), 2.46-1.95 (m, 2H), 2.46, 2.40 (2s, 3H), 2.29, 2.28 (2s, 3H), 2.17, 2.15 (2s, 3H), 2.02 (s, 3H), 1.98, 1.95 (2s, 3H), 1.45, 1.20 (2d, 3H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  171.5, 170.1, 169.9, 169.1, 168.6, 148.2, 147.7, 145.9, 143.2, 141.1, 140.4, 130.9, 130.4, 130.0, 129.8, 120.8, 120.3, 118.8, 118.0, 113.6, 113.4, 102.0, 61.5, 61.4, 60.5, 60.4, 59.3, 59.1, 58.7, 54.8, 54.6, 51.9, 51.7, 48.5, 42.1, 41.9, 41.5, 32.4, 32.3, 23.8, 23.2, 20.5, 19.9, 16.0, 15.8, 9.6. ESI-MS  $m/z$ : Calcd. for  $\text{C}_{36}\text{H}_{41}\text{N}_5\text{O}_{10}\text{S}$ : 735.3. Found ( $\text{M}+\text{H}^+$ ): 736.2.



Compound **3y** (from **2y**):  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.77-7.68 (m, 4H), 7.42-7.26 (m, 4H), 6.53 (s, 1H), 6.05 (bd, 1H), 6.04 (dd, 2H), 5.96-5.87 (m, 1H), 5.74 (s, 1H), 5.58 (bd, 1H), 5.38-5.20 (m, 2H), 5.00 (d, 1H), 4.60-4.55 (m, 4H), 4.33-4.08 (m, 6H), 3.73 (s, 3H), 3.44-3.42 (m, 2H), 3.19-3.13 (m, 1H), 3.05-2.83 (m, 5H), 2.38-2.02 (m, 2H), 2.38 (s, 3H), 2.24 (s, 3H), 2.13 (s, 3H), 2.03 (s, 3H); ESI-MS  $m/z$ : Calcd. for  $\text{C}_{52}\text{H}_{53}\text{N}_5\text{O}_{11}\text{S}_2$ : 987.3. Found ( $\text{M}+\text{H}^+$ ): 988.1.

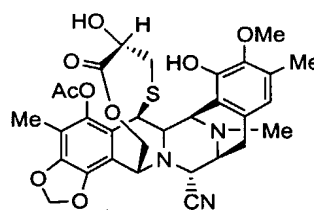


Compound **3z** was also obtained in the reaction of **2y**:  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.76 (d, 2H), 7.66 (dd, 2H), 7.42-7.30 (m, 4H), 6.49 (s, 1H), 6.05 (dd, 2H), 5.67 (bp, 1H), 5.02 (d, 1H), 4.59-4.54 (m, 2H), 4.30 (bs, 1H), 4.25-4.23 (dd, 1H), 4.19-4.09 (m, 3H), 3.71 (s, 3H), 3.68-3.43 (m, 2H), 3.33 (dd, 1H), 3.14-2.85 (m, 5H), 2.46 (dd, 1H), 2.35-2.24 (m, 2H), 2.25 (s, 3H), 2.24 (s, 3H), 2.12 (s, 3H), 2.03 (s, 3H); ESI-MS  $m/z$ : Calcd. for  $\text{C}_{48}\text{H}_{49}\text{N}_5\text{O}_9\text{S}_2$ : 903.3. Found ( $\text{M}+\text{H}^+$ ): 904.2.



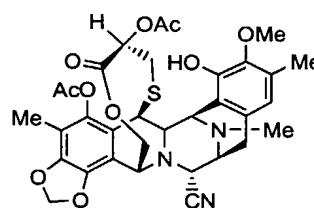
( $\text{M}+\text{H}^+$ ): 624.2.

Compound **15** (from **11**):  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.56 (s, 1H), 6.03 (dd, 2H), 5.74 (s, 1H), 5.04 (d, 2H), 4.54 (bp, 1H), 4.26-4.23 (m, 2H), 4.20-4.14 (m, 2H), 4.02-3.96 (m, 1H), 3.78 (s, 3H), 3.42-3.39 (m, 2H), 2.93-2.90 (m, 2H), 2.31-2.03 (m, 2H), 2.31 (s, 3H), 2.29 (s, 3H), 2.20 (s, 3H), 2.03 (s, 3H); ESI-MS  $m/z$ : Calcd. for  $\text{C}_{31}\text{H}_{33}\text{N}_3\text{O}_9\text{S}$ : 623.2. Found



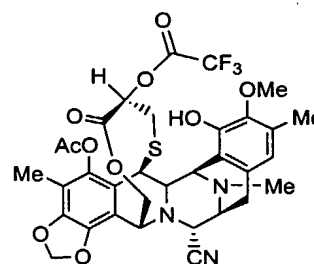
Calcd. for  $\text{C}_{31}\text{H}_{33}\text{N}_3\text{O}_9\text{S}$ : 623.2. Found ( $\text{M}+\text{H}^+$ ): 624.3.

Compound **16\*** (from **12\***):  $^1\text{H}$  NMR (300 MHz,  $45^\circ\text{C}$ ,  $\text{CDCl}_3$ ):  $\delta$  6.49 (s, 1H), 6.04 (dd, 2H), 5.67 (s, 1H), 4.94 (bd, 1H), 4.47 (s, 1H), 4.24-4.17 (m, 3H), 4.05 (d, 1H), 3.80 (s, 3H), 3.57-3.55 (m, 2H), 3.40-3.37 (m, 1H), 2.98-2.90 (m, 1H), 2.73 (d, 1H), 2.51-2.47 (bm, 1H), 2.33 (s, 3H), 2.30 (s, 3H), 2.15 (s, 3H), 2.02 (s, 3H), 1.66 (dd, 1H); ESI-MS  $m/z$ :



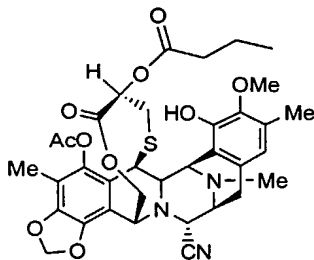
$\delta$  169.7, 168.5, 167.0, 147.2, 145.7, 142.9, 141.1, 140.6, 130.9, 128.7, 121.2, 120.7, 118.1, 118.0, 113.5, 102.0, 71.6, 61.4, 60.2, 60.0, 59.9, 59.0, 54.7, 54.6, 41.6, 41.5, 31.5, 23.9, 20.5, 20.3, 15.8, 9.6. ESI-MS  $m/z$ : Calcd. for  $\text{C}_{33}\text{H}_{35}\text{N}_3\text{O}_{10}\text{S}$ : 665.2. Found ( $\text{M}+\text{H}^+$ ): 666.1.

Compound **17a** (from **13a**):  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.50 (s, 1H), 6.04 (dd, 2H), 5.67 (s, 1H), 5.02-4.99 (m, 2H), 4.56 (bp, 1H), 4.27 (s, 1H), 4.25 (dd, 1H), 4.17 (d, 1H), 4.11 (dd, 1H), 3.79 (s, 3H), 3.44-3.41 (m, 2H), 2.88-2.86 (m, 2H), 2.31-1.97 (m, 2H), 2.31 (s, 3H), 2.28 (s, 3H), 2.16 (s, 3H), 2.03 (s, 3H), 1.97 (s, 3H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):

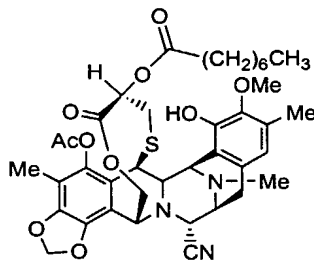


Compound **17b** (from **13b**):  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.46 (s, 1H), 6.05 (dd, 2H), 5.68 (s, 1H), 5.09 (bt, 1H), 5.02 (d, 1H), 4.62 (bp, 1H), 4.31 (s, 1H), 4.24 (dd, 1H), 4.19-4.14 (m, 2H), 3.77 (s, 3H), 3.46-3.40 (m, 2H), 2.93-2.75 (m, 2H), 2.44-2.37 (dd, 1H), 2.32 (s, 3H), 2.26 (s, 3H), 2.16 (s, 3H), 2.10-2.04 (m, 1H), 2.04 (s, 3H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  168.6, 164.9, 147.0, 145.9, 142.9, 141.2, 140.7, 132.2 (CF3?), 130.6, 129.5, 125.1(CF3?), 121.6, 120.5(CF3?),

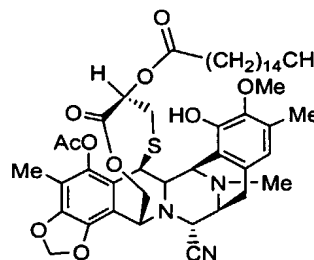
118.0, 117.3, **113.7**, 113.3, 113.3(CF<sub>3</sub>?), 102.1, 74.8, 61.4, 60.6, 60.1, 59.9, 58.9, 54.6, 41.7, 41.6, 31.0, 23.9, 20.4, 15.5, 9.6. ESI-MS m/z: Calcd. for C<sub>33</sub>H<sub>32</sub>F<sub>3</sub>N<sub>3</sub>O<sub>10</sub>S: 719.2. Found (M+H<sup>+</sup>): 720.2.



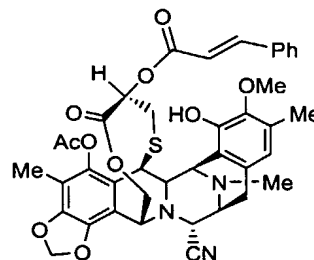
**Compound 17c** (from **13c**): <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 6.47 (s, 1H), 6.04 (dd, 2H), 5.66 (s, 1H), 5.02-4.99 (m, 2H), 4.57 (bp, 1H), 4.28 (s, 1H), 4.24 (dd, 1H), 4.18 (d, 1H), 4.11 (dd, 1H), 3.79 (s, 3H), 3.45-3.41 (m, 2H), 2.87-2.85 (m, 2H), 2.31-1.99 (m, 4H), 2.31 (s, 3H), 2.29 (s, 3H), 2.15 (s, 3H), 2.03 (s, 3H), 1.67-1.55 (m, 2H), 0.97 (t, 3H); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 172.3, 168.5, 167.0, 147.2, 145.8, 142.9, 141.1, 140.6, 131.0, 128.8, 121.2, 120.8, 118.1, 118.1, 113.6, 113.1, 102.0, 71.4, 61.4, 60.2, 59.9, 59.9, 58.8, 54.8, 54.7, 41.6, 35.9, 31.7, 24.0, 20.4, 18.2, 15.8, 13.7, 9.6. ESI-MS m/z: Calcd. for C<sub>33</sub>H<sub>39</sub>N<sub>3</sub>O<sub>10</sub>S: 693.2. Found (M+H<sup>+</sup>): 694.2.



**Compound 17e** (from **13e**): <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 6.47 (s, 1H), 6.03 (dd, 2H), 5.66 (s, 1H), 5.02-4.98 (m, 2H), 4.56 (bp, 1H), 4.27 (s, 1H), 4.24 (dd, 1H), 4.17 (d, 1H), 4.10 (dd, 1H), 3.79 (s, 3H), 3.44-3.42 (m, 2H), 2.87-2.85 (m, 2H), 2.30-1.98 (m, 4H), 2.30 (s, 3H), 2.29 (s, 3H), 2.15 (s, 3H), 2.03 (s, 3H), 1.61-1.57 (m, 2H), 1.31-1.23 (m, 8H), 0.89 (t, 3H); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 172.6, 168.5, 167.0, 147.2, 145.8, 142.9, 141.1, 140.6, 130.0, 128.7, 121.2, 120.8, 118.1, 118.1, 113.6, 113.1, 102.0, 71.4, 61.4, 60.2, 59.9, 58.8, 54.8, 54.7, 41.6, 33.8, 31.7, 31.6, 29.1, 28.9, 24.7, 24.0, 22.6, 20.4, 15.8, 14.1, 9.6. ESI-MS m/z: Calcd. for C<sub>39</sub>H<sub>47</sub>N<sub>3</sub>O<sub>10</sub>S: 749.3. Found (M+H<sup>+</sup>): 750.9.

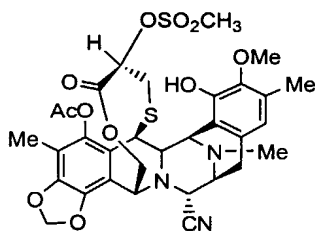


**Compound 17f** (from **13f**): <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 6.48 (s, 1H), 6.04 (dd, 2H), 5.66 (s, 1H), 5.02-4.98 (m, 2H), 4.57 (bp, 1H), 4.28 (s, 1H), 4.25 (dd, 1H), 4.17 (d, 1H), 4.10 (dd, 1H), 3.79 (s, 3H), 3.44-3.40 (m, 2H), 2.87-2.85 (m, 2H), 2.37-1.98 (m, 4H), 2.31 (s, 3H), 2.29 (s, 3H), 2.15 (s, 3H), 2.03 (s, 3H), 1.62-1.55 (m, 2H), 1.35-1.26 (m, 24H), 0.88 (t, 3H); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 172.6, 168.6, 167.1, 147.2, 145.7, 142.8, 141.0, 140.6, 130.9, 128.7, 121.2, 120.7, 118.1, 117.9, 113.5, 113.1, 102.0, 71.4, 61.4, 60.3, 59.8, 58.8, 54.7, 54.6, 41.6, 33.8, 31.9, 31.6, 29.7, 29.5, 29.4, 29.3, 29.2, 24.6, 23.9, 22.7, 20.5, 15.9, 14.1, 9.6. ESI-MS m/z: Calcd. for C<sub>47</sub>H<sub>63</sub>N<sub>3</sub>O<sub>10</sub>S: 861.4. Found (M+H<sup>+</sup>): 862.3.

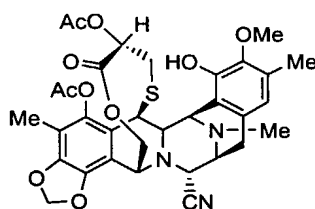


**Compound 17h** (from **13h**): <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 7.64 (d, 1H), 7.55-7.52 (m, 2H), 7.43-7.40 (m, 3H), 6.51 (s, 1H), 6.28 (d, 1H), 6.05 (dd, 2H), 5.70 (s, 1H), 5.17 (bt, 1H), 5.04 (d, 1H), 4.58 (bp, 1H), 4.30 (s, 1H), 4.26 (d, 1H), 4.20 (d, 1H), 4.14 (dd, 1H), 3.79 (s, 3H), 3.45 (d, 1H), 3.42-3.39 (m, 1H), 2.92-2.80 (m, 2H), 2.42 (dd, 1H), 2.31 (s, 3H), 2.26 (s, 3H), 2.15 (s, 3H), 2.09-2.04 (m, 1H), 2.04 (s, 3H); <sup>13</sup>C

NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  168.5, 167.0, 165.6, 147.2, 145.8, 145.6, 142.9, 141.1, 140.6, 134.5, 131.1, 130.4, 128.9, 128.8, 128.1, 121.1, 120.8, 118.1, 118.0, 117.4, 113.6, 113.1, 102.0, 71.9, 61.5, 60.3, 59.9, 58.7, 54.7, 54.7, 41.7, 41.6, 31.8, 24.0, 20.4, 15.9, 9.6. ESI-MS  $m/z$ : Calcd. for  $\text{C}_{40}\text{H}_{39}\text{N}_3\text{O}_{10}\text{S}$ : 753.2. Found ( $\text{M}+\text{H}^+$ ): 754.7.



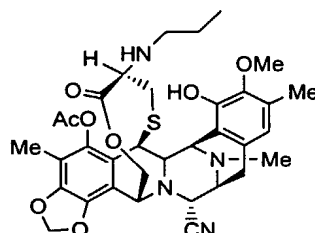
Compound **17II** (from **13II**):  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.43 (s, 1H), 6.04 (dd, 2H), 5.70 (s, 1H), 5.00 (d, 1H), 4.94-4.90 (m, 1H), 4.59 (bp, 1H), 4.28 (s, 1H), 4.24 (d, 1H), 4.17-4.11 (m, 2H), 3.78 (s, 3H), 3.46 (d, 1H), 3.45-3.39 (m, 2H), 3.10 (s, 3H), 2.94-2.78 (m, 2H), 2.50-2.42 (m, 1H), 2.31 (s, 3H), 2.29 (s, 3H), 2.17 (s, 3H), 2.08-2.03 (m, 1H), 2.03 (s, 3H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  168.8, 166.9, 147.8, 146.1, 143.2, 141.4, 140.8, 130.7, 129.4, 121.3, 120.5, 118.2, 118.0, 113.6, 113.3, 102.3, 77.4, 61.4, 61.0, 60.5, 60.1, 59.6, 55.0, 54.8, 41.8, 41.7, 39.6, 33.0, 24.3, 20.6, 16.0, 9.8. ESI-MS  $m/z$ : Calcd. for  $\text{C}_{32}\text{H}_{35}\text{N}_3\text{O}_{11}\text{S}_2$ : 701.2. Found ( $\text{M}+\text{Na}^+$ ): 724.6.



Compound **18a\*** (from **14a\***):  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.49 (s, 1H), 6.04 (dd, 2H), 5.69 (s, 1H), 4.50-4.06 (m, 7H), 3.80 (s, 3H), 3.53 (d, 1H), 3.41-3.38 (m, 1H), 2.96-2.87 (m, 1H), 2.75 (d, 1H), 2.33-1.84 (m, 2H), 2.33 (s, 3H), 2.30 (s, 3H), 2.14 (s, 3H), 2.02 (s, 3H), 1.94 (s, 3H); ESI-MS  $m/z$ : Calcd. for  $\text{C}_{33}\text{H}_{35}\text{N}_3\text{O}_{10}\text{S}$ : 665.2. Found ( $\text{M}+\text{H}^+$ ): 666.7.

## Example 8

**Method H:** To a solution of 1 equiv. of **5** in  $\text{CH}_3\text{CN}$  (0.05M) under Argon at room temperature, were added the amine and 3 equiv. of AcOH. After 40 min. 1.5 equiv. of  $\text{NaBH}_3\text{CN}$  were added and the solution was stirred for 40 min. After this time the reaction mixture was diluted with  $\text{CH}_2\text{Cl}_2$ , neutralized with  $\text{NaHCO}_3$  and extracted with  $\text{CH}_2\text{Cl}_2$ . The organic layer was dried with  $\text{Na}_2\text{SO}_4$ . Flash chromatography gives pure compounds.



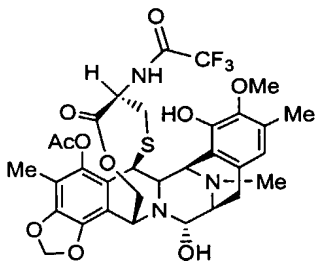
Compound **3o** (using propyl amine):  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.51 (s, 1H), 6.02 (dd, 2H), 5.71 (s, 1H), 5.01 (d, 1H), 4.53 (bp, 1H), 4.24-4.19 (m, 3H), 4.10 (dd, 1H), 3.77 (s, 3H), 3.41-3.40 (m, 2H), 3.17-3.16 (m, 1H), 3.00-2.82 (m, 2H), 2.46-1.97 (m, 4H), 2.29 (s, 3H), 2.27 (s, 3H), 2.16 (s, 3H), 2.02 (s, 3H), 1.44-1.25 (m, 2H), 0.84 (t, 3H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  172.5, 168.6, 147.6, 145.5, 142.9, 140.8, 140.4, 130.6, 129.1, 120.8, 120.7, 118.2, 113.7, 113.2, 101.9, 61.4, 60.1, 60.0, 59.5, 59.0, 54.7, 54.6, 49.2, 41.5, 32.9, 23.8, 23.3, 20.6, 15.7, 11.7, 9.6. ESI-MS  $m/z$ : Calcd. for  $\text{C}_{34}\text{H}_{40}\text{N}_4\text{O}_8\text{S}$ : 664.3. Found ( $\text{M}+\text{H}^+$ ): 665.3.

## Example 9

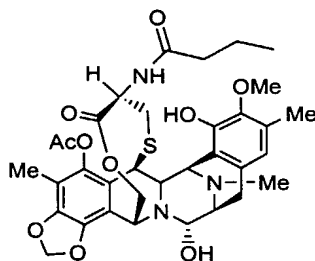
**Method I:** To a solution of 1 equiv. of **3b-i**, **3k-l**, **3q**, **3s**, **3u-v**, **3x-y** or **15** in  $\text{CH}_3\text{CN}/\text{H}_2\text{O}$  3:2 (0.009M) were added 30 equiv. of  $\text{AgNO}_3$ . After 24 h the reaction was



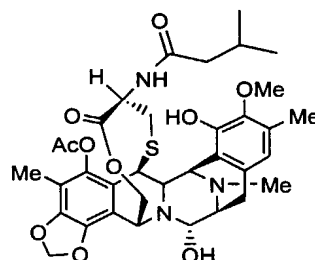
quenched with a mixture 1:1 of saturated solutions of brine and  $\text{NaHCO}_3$ , stirred for 10 min and diluted and extracted with  $\text{CH}_2\text{Cl}_2$ . The organic layer was dried with  $\text{Na}_2\text{SO}_4$ . Chromatography gives pure compounds **4b-i**, **4k-l**, **4q**, **4s**, **4u-v**, **4x-y** or **19**.



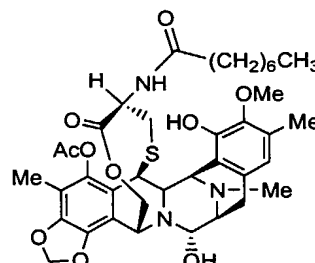
Compound **4b**:  $t_R$  = 48.2 min [HPLC, Symmetry 300 C18,  $5\mu\text{m}$ ,  $250 \times 4.6$  mm,  $\lambda$  = 285 nm, flow = 1.2 ml/min, temp =  $40^\circ\text{C}$ , grad.:  $\text{CH}_3\text{CNaq.}-\text{NH}_4\text{OAc}$  (10mM), 1% DEA, pH = 3.0, 10%-60% (90')];  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.53 (s, 1H), 6.49 (bd, 1H), 6.02 (dd, 2H), 5.69 (bp, 1H), 5.17 (d, 1H), 4.81 (s, 1H), 4.52-4.46 (m, 3H), 4.16-4.10 (m, 2H), 3.74 (s, 3H), 3.51-3.48 (m, 1H), 3.25-3.20 (m, 1H), 2.83-2.80 (m, 2H), 2.45-2.40 (m, 1H), 2.29-2.02 (m, 1H), 2.29 (s, 3H), 2.27 (s, 3H), 2.15 (s, 3H), 2.02 (s, 3H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  168.8, 168.6, 156.8, 156.3, 155.7, 147.4, 145.7, 142.9, 141.1, 140.9, 131.2, 129.7, 120.8, 120.7, 117.9, 114.9, 112.7, 101.9, 81.4, 62.0, 60.1, 57.7, 57.6, 56.0, 54.8, 52.9, 42.2, 41.3, 29.7, 23.6, 20.5, 15.6, 9.6. ESI-MS  $m/z$ : Calcd. for  $\text{C}_{32}\text{H}_{34}\text{F}_3\text{N}_3\text{O}_{10}\text{S}$ : 709.2. Found ( $\text{M}-\text{H}_2\text{O}+\text{H}^+$ ): 692.2.



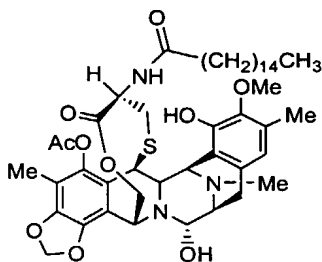
Compound **4c**:  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.56 (s, 1H), 6.01 (dd, 2H), 5.70 (s, 1H), 5.57 (bd, 1H), 5.15 (d, 1H), 4.77 (s, 1H), 4.61-4.57 (m, 1H), 4.50-4.42 (m, 2H), 4.15-4.07 (m, 2H), 3.77 (s, 3H), 3.49-3.47 (m, 1H), 3.23-3.15 (m, 1H), 2.85-2.82 (m, 2H), 2.32-1.98 (m, 4H), 2.32 (s, 3H), 2.28 (s, 3H), 2.13 (s, 3H), 2.01 (s, 3H), 1.65-1.58 (m, 2H), 0.96 (t, 3H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  171.8, 170.5, 147.9, 145.6, 143.0, 141.0, 140.8, 131.6, 128.8, 121.0, 120.7, 118.9, 115.3, 101.8, 81.5, 61.6, 60.3, 57.8, 57.6, 56.0, 55.0, 51.9, 42.0, 41.3, 38.3, 32.6, 23.7, 20.5, 18.9, 16.1, 13.8, 9.6. ESI-MS  $m/z$ : Calcd. for  $\text{C}_{34}\text{H}_{41}\text{N}_3\text{O}_{10}\text{S}$ : 683.2. Found ( $\text{M}-\text{H}_2\text{O}+\text{H}^+$ ): 666.3.



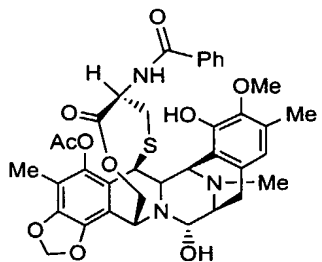
Compound **4d**:  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.56 (s, 1H), 6.02 (dd, 2H), 5.72 (bs, 1H), 5.55 (bd, 1H), 5.15 (d, 1H), 4.78 (s, 1H), 4.64-4.60 (m, 1H), 4.48-4.42 (m, 2H), 4.17-4.12 (m, 1H), 4.09 (dd, 1H), 3.77 (s, 3H), 3.53-3.48 (m, 1H), 3.27-3.20 (m, 1H), 2.90-2.75 (m, 2H), 2.34-1.91 (m, 5H), 2.34 (s, 3H), 2.28 (s, 3H), 2.14 (s, 3H), 2.01 (s, 3H), 0.98 (d, 3H), 0.93 (d, 3H); ESI-MS  $m/z$ : Calcd. for  $\text{C}_{35}\text{H}_{43}\text{N}_3\text{O}_{10}\text{S}$ : 697.3. Found ( $\text{M}-\text{H}_2\text{O}+\text{H}^+$ ): 680.0.



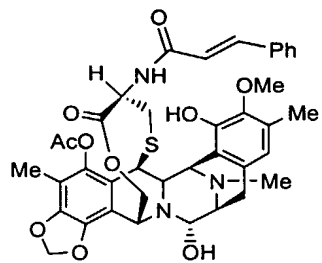
Compound **4e**:  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.56 (s, 1H), 6.02 (d, 2H), 5.70 (s, 1H), 5.55 (bd, 1H), 5.15 (d, 1H), 4.77 (s, 1H), 4.61-4.55 (m, 1H), 4.50-4.42 (m, 2H), 4.17-4.14 (m, 1H), 4.08 (dd, 1H), 3.77 (s, 3H), 3.51-3.48 (m, 1H), 3.26-3.19 (m, 1H), 2.86-2.79 (m, 2H), 2.32-1.98 (m, 4H), 2.32 (s, 3H), 2.28 (s, 3H), 2.15 (s, 3H), 2.01 (s, 3H), 1.65-1.58 (m, 2H), 1.37-1.22 (m, 8H), 0.89 (t, 3H); ESI-MS  $m/z$ : Calcd. for  $\text{C}_{38}\text{H}_{49}\text{N}_3\text{O}_{10}\text{S}$ : 739.3. Found ( $\text{M}-\text{H}_2\text{O}+\text{H}^+$ ): 722.3.



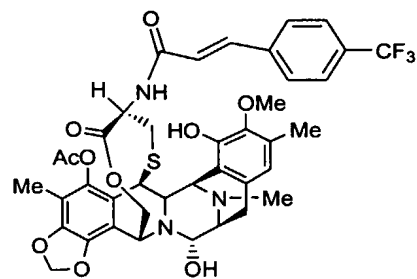
Compound **4f**:  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.56 (s, 1H), 6.02 (dd, 2H), 5.70 (s, 1H), 5.57-5.53 (bd, 1H), 5.14 (d, 1H), 4.77 (s, 1H), 4.58 (ddd, 1H), 4.47-4.43 (m, 2H), 4.18-4.13 (m, 1H), 4.08 (dd, 1H), 3.77 (s, 3H), 3.50-3.46 (m, 1H), 3.25-3.19 (m, 1H), 2.88-2.82 (m, 1H), 2.32-1.95 (m, 4H), 2.32 (s, 3H), 2.28 (s, 3H), 2.15 (s, 3H), 2.01 (s, 3H), 1.40-1.20 (m, 26H), 0.88 (t, 3H); ESI-MS  $m/z$ : Calcd. for  $\text{C}_{46}\text{H}_{65}\text{N}_3\text{O}_{10}\text{S}$ : 851.4. Found ( $\text{M}-\text{H}_2\text{O}+\text{H}^+$ ): 834.5.



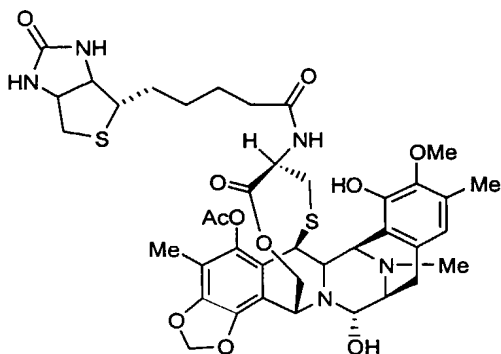
Compound **4g**:  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.70-7.67 (m, 2H), 7.56-7.45 (m, 3H), 6.49 (s, 1H), 6.42 (d, 1H), 6.03 (dd, 2H), 5.66 (s, 1H), 5.20 (d, 1H), 4.82 (s, 1H), 4.73 (dt, 1H), 4.52-4.45 (m, 2H), 4.16-4.10 (m, 2H), 3.61 (s, 3H), 3.52 (bd, 1H), 3.27-3.22 (m, 1H), 2.90-2.85 (m, 2H), 2.62-2.56 (m, 1H), 2.28-1.92 (m, 1H), 2.28 (s, 3H), 2.13 (s, 3H), 2.03 (s, 3H), 1.92 (s, 3H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  170.4, 168.5, 166.4, 147.6, 145.7, 142.9, 141.1, 140.9, 134.4, 131.5, 129.3, 128.6, 127.0, 125.1, 121.2, 120.5, 115.1, 112.6, 101.8, 81.5, 61.6, 60.1, 57.9, 56.0, 55.0, 53.3, 42.1, 41.3, 32.7, 23.9, 20.4, 15.6, 9.6; ESI-MS  $m/z$ : Calcd. for  $\text{C}_{37}\text{H}_{39}\text{N}_3\text{O}_{10}\text{S}$ : 717.2. Found ( $\text{M}-\text{H}_2\text{O}+\text{H}^+$ ): 699.9.



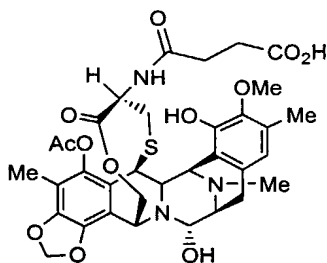
Compound **4h**:  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.60 (d, 1H), 7.55-7.51 (m, 2H), 7.44-7.38 (m, 3H), 6.65 (s, 1H), 6.25 (d, 1H), 6.02 (dd, 2H), 5.80 (d, 1H), 5.71 (s, 1H), 5.18 (d, 1H), 4.79 (s, 1H), 4.69 (ddd, 1H), 4.49-4.43 (m, 2H), 4.16-4.09 (m, 2H), 3.68 (s, 3H), 3.51-3.49 (m, 1H), 3.26-3.20 (m, 1H), 2.89-2.86 (m, 2H), 2.52-2.47 (m, 1H), 2.29-2.03 (m, 1H), 2.29 (s, 3H), 2.27 (s, 3H), 2.17 (s, 3H), 2.03 (s, 3H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  170.4, 168.5, 164.5, 147.9, 145.6, 143.0, 141.8, 141.5, 141.0, 140.8, 134.8, 131.6, 129.7, 129.0, 128.8, 127.9, 121.0, 120.5, 120.1, 118.7, 115.2, 112.7, 101.8, 81.6, 61.7, 60.2, 57.7, 57.6, 56.0, 54.9, 52.7, 42.0, 41.3, 32.5, 23.7, 20.5, 16.3, 9.6. ESI-MS  $m/z$ : Calcd. for  $\text{C}_{39}\text{H}_{41}\text{N}_3\text{O}_{10}\text{S}$ : 743.2. Found ( $\text{M}-\text{H}_2\text{O}+\text{H}^+$ ): 726.3.



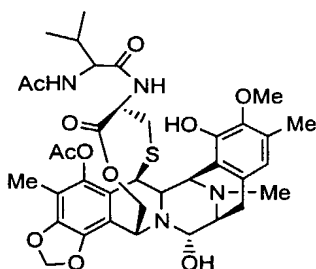
Compound **4i**:  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.83 (s, 1H), 7.65-7.51 (m, 4H), 6.65 (s, 1H), 6.29 (d, 1H), 6.03 (dd, 2H), 5.81 (d, 1H), 5.71 (s, 1H), 5.18 (d, 1H), 4.79 (s, 1H), 4.71-4.67 (m, 1H), 4.49-4.47 (m, 2H), 4.16-4.09 (m, 2H), 3.70 (s, 3H), 3.51-3.49 (m, 1H), 3.23-3.20 (m, 1H), 2.88-2.86 (m, 2H), 2.47-2.33 (m, 1H), 2.30-2.02 (m, 1H), 2.30 (s, 3H), 2.28 (s, 3H), 2.16 (s, 3H), 2.02 (s, 3H); ESI-MS  $m/z$ : Calcd. for  $\text{C}_{40}\text{H}_{40}\text{N}_3\text{F}_3\text{O}_{10}\text{S}$ : 811.2. Found ( $\text{M}-\text{H}_2\text{O}+\text{H}^+$ ): 794.2.



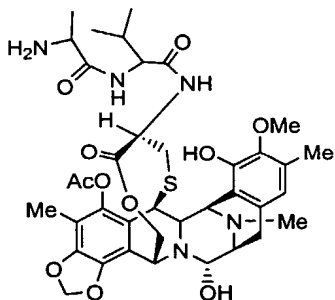
Compound **4k**:  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  8.32 (bp, 1H), 6.56 (s, 1H), 6.54 (s, 1H), 6.01 (dd, 2H), 5.48 (bd, 1H), 5.14 (d, 1H), 4.75 (s, 1H), 4.68-4.63 (m, 1H), 4.55-4.45 (m, 3H), 4.33 (dd, 1H), 4.22 (bp, 1H), 4.05 (dd, 1H), 3.80 (s, 3H), 3.53-3.45 (m, 1H), 3.22-3.13 (m, 1H), 3.10-3.02 (m, 1H), 2.94-2.84 (m, 3H), 2.66 (d, 1H), 2.34-1.91 (m, 4H), 2.34 (s, 3H), 2.30 (s, 3H), 2.10 (bs, 3H), 2.01 (bs, 3H), 1.75-1.22 (m, 6H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  171.0, 170.4, 163.7, 148.9, 145.5, 142.7, 141.1, 140.5, 131.8, 128.8, 122.2, 120.3, 112.6, 101.7, 82.0, 62.1, 60.1, 59.7, 57.2, 56.4, 55.7, 55.3, 51.2, 41.9, 41.2, 41.1, 34.3, 32.9, 27.8, 27.5, 24.8, 23.9, 20.7, 16.2, 9.6; ESI-MS  $m/z$ : Calcd. for  $\text{C}_{40}\text{H}_{49}\text{N}_5\text{O}_{11}\text{S}_2$ : 840.0. Found ( $\text{M}-\text{H}_2\text{O}^+$ ): 822.3.



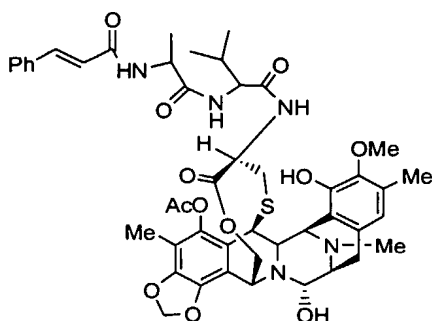
Compound **4l**:  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.58 (s, 1H), 6.02 (dd, 2H), 5.82-5.72 (bm, 2H), 5.15 (d, 1H), 4.79 (bs, 1H), 4.57-4.45 (m, 3H), 4.22-4.15 (bp, 1H), 4.11 (dd, 1H), 3.78 (s, 3H), 3.59-3.49 (bp, 1H), 3.30-3.23 (bp, 1H), 2.91-2.83 (m, 2H), 2.68-2.45 (m, 4H), 2.35-2.02 (m, 2H), 2.32 (s, 3H), 2.29 (s, 3H), 2.17 (s, 3H), 2.01 (s, 3H); ESI-MS  $m/z$ : Calcd. for  $\text{C}_{34}\text{H}_{39}\text{N}_3\text{O}_{12}\text{S}$ : 713.2. Found ( $\text{M}-\text{H}_2\text{O}+\text{H}^+$ ): 696.2.



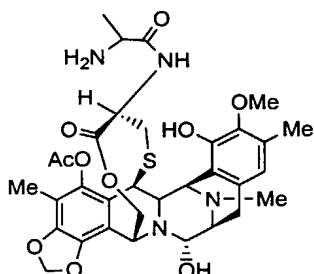
Compound **4q**:  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.55 (s, 1H), 6.07 (d, 1H), 6.02 (d, 2H), 5.75 (s, 1H), 5.64 (d, 1H), 5.15 (d, 1H), 4.78 (s, 1H), 4.67-4.62 (m, 1H), 4.50-4.45 (m, 2H), 4.14-4.09 (m, 3H), 3.80 (s, 3H), 3.51-3.47 (m, 1H), 3.25-3.20 (m, 1H), 2.85-2.82 (m, 2H), 2.50 (s, 3H), 2.29-1.98 (m, 3H), 2.29 (s, 3H), 2.13 (s, 3H), 2.02 (s, 3H), 1.98 (s, 3H), 1.06 (d, 3H), 0.97 (d, 3H); ESI-MS  $m/z$ : Calcd. for  $\text{C}_{37}\text{H}_{46}\text{N}_4\text{O}_{11}\text{S}$ : 754.3. Found ( $\text{M}-\text{H}_2\text{O}+\text{H}^+$ ): 737.3.



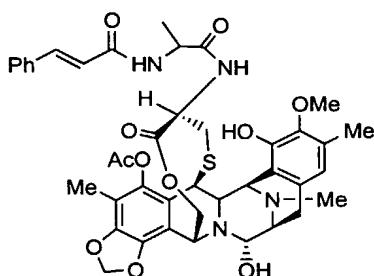
Compound **4s** ESI-MS  $m/z$ : Calcd. for  $\text{C}_{38}\text{H}_{49}\text{N}_5\text{O}_{11}\text{S}$ : 783.3. Found ( $\text{M}^+$ ): 766.3.



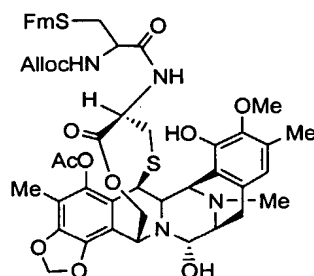
Compound **4u**: ESI-MS  $m/z$ : Calcd. for  $C_{47}H_{55}N_5O_{12}S$ : 914.0. Found ( $M-H_2O+H^+$ ): 897.0.



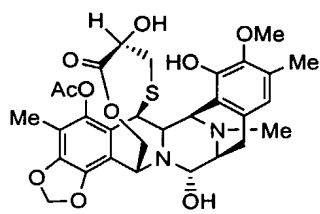
Compound **4v**:  $^1H$  NMR (300 MHz,  $CDCl_3$ ):  $\delta$  6.70 (bp, 1H), 6.54 (s, 1H), 6.02 (d, 2H), 5.16 (d, 1H), 4.79 (s, 1H), 4.55-4.48 (m, 3H), 4.15-4.07 (m, 2H), 3.77 (s, 3H), 3.52-3.49 (m, 1H), 3.32-3.21 (m, 2H), 2.85-2.80 (m, 2H), 2.31-2.02 (m, 2H), 2.31 (s, 3H), 2.29 (s, 3H), 2.12 (s, 3H), 2.02 (s, 3H), 1.26 (d, 3H); ESI-MS  $m/z$ : Calcd. for  $C_{33}H_{40}N_4O_{10}S$ : 684.2. Found ( $M-H_2O+H^+$ ): 667.2.



Compound **4x**: ESI-MS  $m/z$ : Calcd. for  $C_{42}H_{46}N_4O_{11}S$ : 814.9. Found ( $M-H_2O+H^+$ ): 797.9.



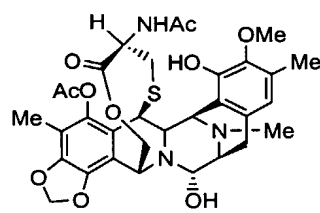
Compound **4y**:  $^1H$  NMR (300 MHz,  $CDCl_3$ ):  $\delta$  7.77-7.67 (m, 4H), 7.42-7.28 (m, 4H), 6.55 (s, 1H), 6.18-6.06 (bp, 1H), 6.02 (dd, 2H), 6.03-5.86 (m, 1H), 5.70 (bs, 1H), 5.58 (bd, 1H), 5.35-5.20 (m, 2H), 5.15 (d, 1H), 4.79 (s, 1H), 4.60-4.55 (m, 3H), 4.46 (d, 1H), 4.20-4.11 (m, 4H), 3.73 (s, 3H), 3.49-3.47 (m, 1H), 3.21-3.15 (m, 2H), 3.06-2.70 (m, 6H), 2.38-2.11 (m, 2H), 2.38 (s, 3H), 2.24 (s, 3H), 2.11 (s, 3H), 2.02 (s, 3H);  $^{13}C$  NMR (75 MHz,  $CDCl_3$ ):  $\delta$  169.8, 168.9, 147.8, 145.8, 145.7, 143.0, 141.0, 140.8, 132.5, 131.4, 127.5, 127.1, 127.0, 125.0, 125.0, 120.6, 119.8, 117.9, 115.1, 101.8, 81.4, 65.8, 61.6, 60.3, 57.8, 55.9, 55.0, 54.4, 52.4, 47.0, 42.1, 41.3, 37.2, 36.5, 33.3, 23.6, 20.4, 16.1, 9.6. ESI-MS  $m/z$ : Calcd. for  $C_{51}H_{54}N_4O_{12}S_2$ : 978.3. Found ( $M-H_2O+H^+$ ): 961.3.



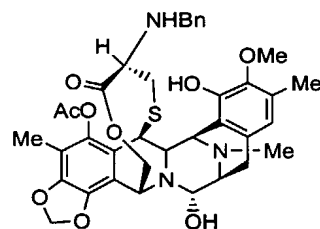
**Compound 19:**  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.58 (s, 1H), 6.01 (dd, 2H), 5.71 (s, 1H), 5.16 (d, 1H), 4.76 (s, 1H), 4.47-4.43 (m, 2H), 4.15-4.11 (m, 1H), 4.08 (dd, 1H), 4.01-3.96 (m, 1H), 3.78 (s, 3H), 3.49-3.45 (m, 1H), 3.21-3.17 (m, 1H), 2.88-2.83 (m, 2H), 2.35-2.02 (m, 2H), 2.31 (s, 3H), 2.29 (s, 3H), 2.17 (s, 3H), 2.02 (s, 3H); ESI-MS  $m/z$ : Calcd. for  $\text{C}_{30}\text{H}_{34}\text{N}_2\text{O}_{10}\text{S}$ : 614.2. Found ( $\text{M}-\text{H}_2\text{O}+\text{H}^+$ ): 597.1.

### Example 10

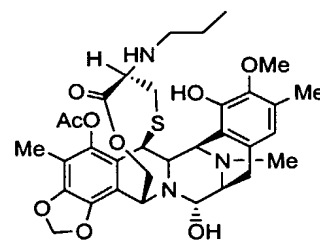
**Method J:** To a solution of 1 equiv. of **3a**, **3n-p**, **3r**, **3t**, **17a**, **17cc**, **17e-f**, **17h**, **17ll** or **18a\*** in THF/ $\text{H}_2\text{O}$  4:1 (0.03M) were added 5 equiv. of CuBr. After 24 h the reaction was diluted with  $\text{CH}_2\text{Cl}_2$ , washed with saturated solutions of  $\text{NaHCO}_3$  and brine, and the organic layer dried with  $\text{Na}_2\text{SO}_4$ . Chromatography gives pure compounds **4a**, **4n-p**, **4r**, **4t**, **21a**, **21c**, **21e-f**, **21h**, **21ll** or **22a\***.



**Compound 4a:**  $t_R$  = 24.6 min [HPLC, Symmetry 300 C18, 5 $\mu\text{m}$ , 250x4.6 mm,  $\lambda$  = 285 nm, flow = 1.2 ml/min, temp = 40°C, grad.:  $\text{CH}_3\text{CN}:\text{aq.}-\text{NH}_4\text{OAc}$  (10mM), 1% DEA, pH = 3.0, 10%-60% (90')];  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.57 (s, 1H), 6.02 (dd, 2H), 5.79 (bs, 1H), 5.60 (bd, 1H), 5.15 (d, 1H), 4.77 (s, 1H), 4.56 (ddd, 1H), 4.46-4.43 (m, 2H), 4.15 (dd, 1H), 4.09 (dd, 1H), 3.77 (s, 3H), 3.49-3.47 (m, 1H), 3.23-3.20 (m, 1H), 2.91-2.76 (m, 2H), 2.31-2.11 (m, 2H), 2.31 (s, 3H), 2.28 (s, 3H), 2.14 (s, 3H), 2.01 (s, 3H), 1.89 (s, 3H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  170.4, 168.8, 168.5, 148.0, 145.6, 143.0, 141.0, 140.7, 131.5, 128.8, 120.9, 120.6, 118.9, 115.2, 112.7, 101.8, 81.5, 61.6, 60.2, 57.7, 57.4, 55.9, 55.0, 52.1, 52.0, 41.3, 32.4, 23.6, 22.9, 20.5, 16.1, 9.5. ESI-MS  $m/z$ : Calcd. for  $\text{C}_{32}\text{H}_{37}\text{N}_3\text{O}_{10}\text{S}$ : 655.2. Found ( $\text{M}-\text{H}_2\text{O}+\text{H}^+$ ): 638.1.

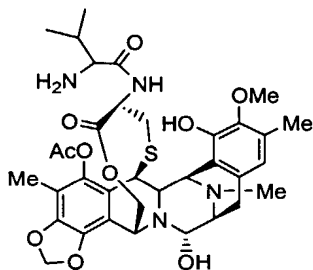


**Compound 4n:**  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.29-7.21 (m, 5H), 6.39 (s, 1H), 5.99 (dd, 2H), 5.66 (s, 1H), 5.16 (d, 1H), 4.74 (s, 1H), 4.52 (d, 1H), 4.44 (bp, 1H), 4.12 (d, 1H), 4.03 (dd, 1H), 3.73 (s, 3H), 3.64 (dd, 2H), 3.48-3.47 (m, 1H), 3.21-3.17 (m, 2H), 2.95 (d, 1H), 2.84-2.75 (m, 1H), 2.35-2.30 (m, 1H), 2.30 (s, 3H), 2.16 (s, 3H), 2.07-2.01 (m, 1H), 2.01 (s, 3H), 1.93 (s, 3H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  172.6, 168.6, 147.6, 145.4, 142.8, 140.9, 140.8, 140.2, 131.3, 130.8, 129.1, 128.8, 128.2, 126.8, 121.4, 120.9, 117.9, 115.6, 112.4, 101.7, 81.8, 60.9, 60.1, 59.5, 57.8, 57.6, 56.1, 54.9, 51.4, 41.8, 41.3, 33.3, 23.6, 20.6, 15.2, 9.6. ESI-MS  $m/z$ : Calcd. for  $\text{C}_{37}\text{H}_{41}\text{N}_3\text{O}_9\text{S}$ : 703.3. Found ( $\text{M}-\text{H}_2\text{O}+\text{H}^+$ ): 686.7.

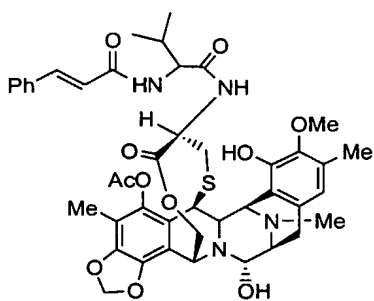


**Compound 4o:**  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.53 (s, 1H), 6.00 (dd, 2H), 5.69 (bp, 1H), 5.14 (d, 1H), 4.74 (s, 1H), 4.44-4.49 (m, 2H), 4.13 (bd, 1H), 4.04 (dd, 1H), 3.78 (s, 3H), 3.49-3.47 (m, 1H), 3.22-3.16 (m, 2H), 2.96-2.75 (m, 2H), 2.51-2.02 (m, 4H), 2.29 (s, 3H), 2.28 (s, 3H), 2.15 (s, 3H), 2.02 (s,

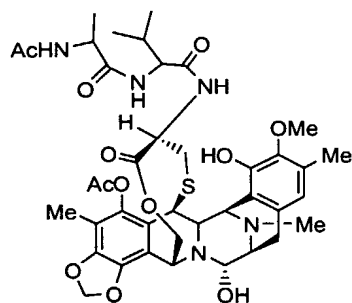
3H), 1.42-1.25 (m, 2H), 0.86 (t, 3H); ESI-MS  $m/z$ : Calcd. for  $C_{33}H_{41}N_3O_9S$ : 655.3. Found ( $M-H_2O+H^+$ ): 638.3.



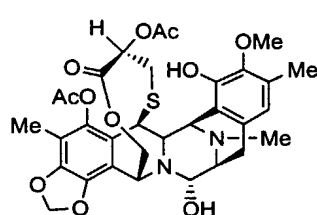
Compound **4p**:  $^1H$  NMR (300 MHz,  $CDCl_3$ ):  $\delta$  6.67 (bp, 1H), 6.52 (s, 1H), 6.02 (dd, 2H), 5.67 (bp, 1H), 5.16 (d, 1H), 4.80 (s, 1H), 4.63-4.60 (m, 1H), 4.49 (d, 1H), 4.45 (bp, 1H), 4.16 (d, 1H), 4.08 (dd, 1H), 3.77 (s, 3H), 3.52-3.9 (m, 1H), 3.25-3.20 (m, 1H), 3.00 (d, 1H), 2.85-2.82 (m, 2H), 2.32-2.02 (m, 3H), 2.32 (s, 3H), 2.29 (s, 3H), 2.11 (s, 3H), 2.02 (s, 3H), 0.99 (d, 3H), 0.81 (d, 3H); ESI-MS  $m/z$ : Calcd. for  $C_{35}H_{44}N_4O_{10}S$ : 712.3. Found ( $M-H_2O+H^+$ ): 695.2



Compound **4r**:  $^1H$  NMR (300 MHz,  $CDCl_3$ ):  $\delta$  7.59 (d, 1H), 7.49-7.46 (m, 2H), 7.36-7.34 (m, 3H), 6.58 (s, 1H), 6.42 (d, 1H), 6.34 (d, 1H), 6.01 (dd, 2H), 5.79 (s, 1H), 5.69 (d, 1H), 5.15 (d, 1H), 4.78 (s, 1H), 4.70-4.65 (m, 1H), 4.50-4.47 (m, 2H), 4.28 (dd, 1H), 4.15 (d, 1H), 4.10 (dd, 1H), 3.81 (s, 3H), 3.49 (d, 1H), 3.25-3.22 (m, 1H), 2.85-2.83 (m, 2H), 2.57 (s, 3H), 2.28-2.14 (m, 3H), 2.28 (s, 3H), 2.14 (s, 3H), 2.01 (s, 3H), 1.10 (d, 3H), 1.01 (d, 3H);  $^{13}C$  NMR (75 MHz,  $CDCl_3$ ):  $\delta$  170.1, 170.0, 168.6, 165.2, 148.0, 145.7, 143.2, 141.12, 140.84, 134.8, 131.2, 129.9, 129.6, 128.8, 127.8, 120.8, 120.7, 120.6, 118.4, 115.3, 112.7, 101.8, 81.5, 61.7, 60.4, 57.8, 57.7, 57.5, 56.0, 55.0, 52.0, 42.2, 41.3, 32.7, 32.6, 23.7, 20.5, 19.2, 18.0, 16.4, 9.6. ESI-MS  $m/z$ : Calcd. for  $C_{44}H_{50}N_4O_{11}S$ : 842.9. Found ( $M-H_2O+H^+$ ): 825.3.

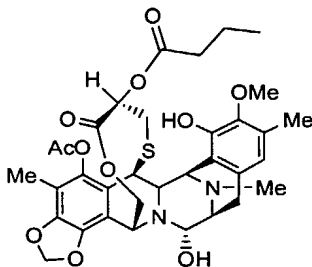


Compound **4t**:  $^1H$  NMR (300 MHz,  $CDCl_3$ ):  $\delta$  6.54 (s, 1H), 6.49 (d, 1H), 6.21-6.16 (m, 1H), 6.07-5.96 (m, 2H), 5.78 (s, 1H), 5.63 (bd, 1H), 5.14 (d, 1H), 4.81, 4.78 (2s, 1H), 4.64-4.60 (m, 1H), 4.53-4.08 (m, 6H), 3.78, 3.7s (2s, 3H), 3.65-3.45 (m, 1H), 3.33-3.22 (m, 1H), 2.90-2.66 (m, 2H), 2.48 (s, 3H), 2.28-1.99 (m, 3H), 2.28 (s, 3H), 2.16, 2.13 (2s, 3H), 2.01 (s, 3H), 1.99 (s, 3H), 1.37, 1.34 (2d, 3H), 1.08-1.03 (m, 3H), 0.96-0.93 (m, 3H);  $^{13}C$  NMR (75 MHz,  $CDCl_3$ ):  $\delta$  171.8, 170.1, 169.6, 169.5, 169.5, 168.7, 147.9, 145.7, 143.1, 141.0, 140.8, 131.3, 129.6, 120.7, 120.4, 118.5, 115.2, 112.6, 101.8, 81.4, 61.6, 60.4, 60.3, 57.7, 57.6, 57.5, 55.9, 54.9, 51.9, 48.9, 48.9, 42.2, 41.3, 32.5, 32.3, 23.6, 23.2, 20.5, 19.2, 19.1, 18.6, 17.7, 17.6, 16.3, 9.6. ESI-MS  $m/z$ : Calcd. for  $C_{40}H_{51}N_5O_{12}S$ : 825.3. Found ( $M-H_2O+H^+$ ): 808.3.

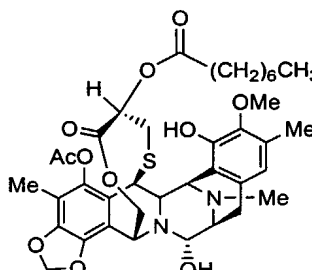


Compound **21a**:  $^1H$  NMR (300 MHz,  $CDCl_3$ ):  $\delta$  6.52 (s, 1H), 6.01 (dd, 2H), 5.64 (s, 1H), 5.13 (d, 1H), 5.00 (t, 1H), 4.76 (s, 1H), 4.48-4.45 (m, 2H), 4.15-4.12 (m, 1H), 4.02 (dd, 1H), 3.79 (s, 3H), 3.50-3.47 (m, 1H), 3.22-3.17 (m, 1H), 2.82-2.79 (m, 2H), 2.30-1.98 (m, 2H), 2.30 (s, 3H), 2.29 (s, 3H), 2.15 (s,

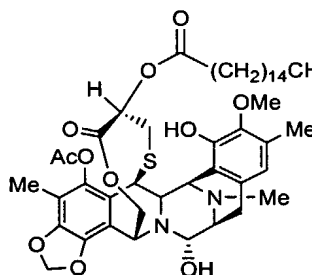
3H), 2.02 (s, 3H), 1.98 (s, 3H); ESI-MS  $m/z$ : Calcd. for  $C_{32}H_{36}N_2O_{11}S$ : 656.2. Found ( $M-H_2O+H^+$ ): 639.2.



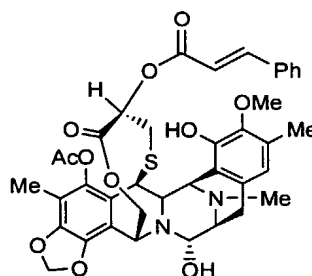
Compound **21c**:  $^1H$  NMR (300 MHz,  $CDCl_3$ ):  $\delta$  6.45 (s, 1H), 6.01 (dd, 2H), 5.63 (s, 1H), 5.13 (d, 1H), 5.03 (t, 1H), 4.77 (s, 1H), 4.50-4.48 (m, 2H), 4.14 (bd, 1H), 4.02 (dd, 1H), 3.79 (s, 3H), 3.51-3.49 (bd, 1H), 3.21-3.12 (m, 1H), 2.85-2.75 (m, 2H), 2.31-2.02 (m, 4H), 2.31 (s, 3H), 2.29 (s, 3H), 2.13 (s, 3H), 2.02 (s, 3H), 1.66-1.56 (m, 2H), 0.97 (t, 3H);  $^{13}C$  NMR (75 MHz,  $CDCl_3$ ):  $\delta$  172.4, 168.6, 166.9, 147.1, 145.6, 142.8, 141.1, 131.8, 128.6, 125.1, 121.4, 115.4, 101.8, 81.5, 71.6, 61.2, 60.2, 58.2, 57.9, 56.1, 55.0, 41.8, 41.4, 36.0, 31.6, 23.9, 20.4, 18.3, 15.8, 13.7, 9.6. ESI-MS  $m/z$ : Calcd. for  $C_{34}H_{40}N_2O_{11}S$ : 684.2. Found ( $M-H_2O+H^+$ ): 667.2.



Compound **21e**:  $^1H$  NMR (300 MHz,  $CDCl_3$ ):  $\delta$  6.49 (s, 1H), 6.01 (dd, 2H), 5.63 (s, 1H), 5.13 (d, 1H), 5.02 (t, 1H), 4.76 (s, 1H), 4.47-4.46 (m, 2H), 4.13 (dd, 1H), 4.02 (dd, 1H), 3.79 (s, 3H), 3.50-3.49 (m, 1H), 3.21-3.19 (m, 1H), 2.81-2.78 (m, 2H), 2.30-2.02 (m, 4H), 2.30 (s, 3H), 2.29 (s, 3H), 2.13 (s, 3H), 2.02 (s, 3H), 1.62-1.54 (m, 2H), 1.32-1.25 (m, 8H), 0.90 (t, 3H);  $^{13}C$  NMR (75 MHz,  $CDCl_3$ ):  $\delta$  172.6, 168.6, 166.9, 147.1, 145.5, 142.8, 141.1, 141.0, 131.7, 128.6, 121.4, 117.9, 115.4, 112.3, 101.8, 81.5, 71.5, 61.2, 60.2, 58.1, 57.9, 56.1, 55.0, 41.8, 41.4, 33.9, 31.7, 31.6, 29.1, 28.9, 24.7, 23.9, 22.6, 20.4, 15.8, 14.1, 9.6. ESI-MS  $m/z$ : Calcd. for  $C_{38}H_{48}N_2O_{11}S$ : 740.3. Found ( $M-H_2O+H^+$ ): 723.2.

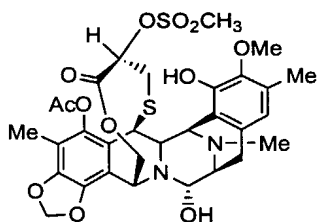


Compound **21f**:  $^1H$  NMR (300 MHz,  $CDCl_3$ ):  $\delta$  6.50 (s, 1H), 6.01 (dd, 2H), 5.63 (s, 1H), 5.13 (d, 1H), 5.02 (t, 1H), 4.77 (bs, 1H), 4.50-4.48 (m, 2H), 4.16-4.12 (m, 1H), 4.02 (dd, 1H), 3.79 (s, 3H), 3.51-3.49 (m, 1H), 3.22-3.19 (m, 1H), 2.82-2.77 (m, 2H), 2.37-2.02 (m, 7H), 2.30 (s, 3H), 2.29 (s, 3H), 2.02 (s, 3H), 1.65-1.59 (m, 2H), 1.40-1.16 (m, 24H), 0.88 (t, 3H); ESI-MS  $m/z$ : Calcd. for  $C_{46}H_{64}N_2O_{10}S$ : 852.4. Found ( $M-H_2O+H^+$ ): 835.4.

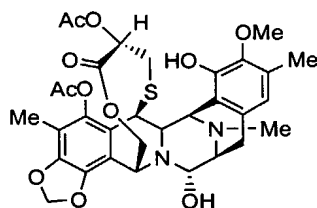


Compound **21h**:  $^1H$  NMR (300 MHz,  $CDCl_3$ ):  $\delta$  7.64 (d, 1H), 7.55-7.52 (m, 2H), 7.42-7.40 (m, 3H), 6.54 (s, 1H), 6.30 (d, 1H), 6.02 (dd, 2H), 5.65 (s, 1H), 5.19-5.16 (m, 2H), 4.79 (s, 1H), 4.50-4.49 (m, 2H), 4.15 (d, 1H), 4.05 (dd, 1H), 3.79 (s, 3H), 3.51 (d, 1H), 3.22-3.19 (m, 1H), 2.89-2.76 (m, 2H), 2.45-2.41 (m, 1H), 2.31 (s, 3H), 2.26 (s, 3H), 2.13 (s, 3H), 2.13-2.03 (m, 1H), 2.03 (s, 3H);  $^{13}C$  NMR (75 MHz,  $CDCl_3$ ):  $\delta$  168.6, 166.9, 165.7, 147.1, 145.5, 145.4, 142.8, 141.1,

141.0, 134.6, 131.9, 130.3, 128.9, 128.1, 121.3, 117.6, 115.4, 112.3, 101.8, 81.5, 72.0, 61.2, 60.3, 58.2, 57.9, 56.1, 55.0, 41.9, 41.4, 31.8, 23.9, 20.4, 15.9, 9.6. ESI-MS  $m/z$ : Calcd. for  $C_{39}H_{40}N_2O_{11}S$ : 744.2. Found ( $M-H_2O+H^+$ ): 727.2.



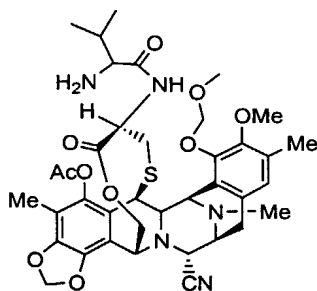
Compound **21II**:  $^1H$  NMR (300 MHz,  $CDCl_3$ ):  $\delta$  6.45 (s, 1H), 6.01 (dd, 2H), 5.68 (s, 1H), 5.12 (d, 1H), 4.92 (t, 1H), 4.78 (s, 1H), 4.53-4.42 (m, 2H), 4.15-4.03 (m, 2H), 3.78 (s, 3H), 3.51-3.48 (m, 1H), 3.24-3.20 (m, 1H), 3.10 (s, 3H), 2.83-2.78 (m, 2H), 2.50-2.42 (m, 1H), 2.31 (s, 3H), 2.30 (s, 3H), 2.17 (s, 3H), 2.08-2.03 (m, 1H), 2.03 (s, 3H); ESI-MS  $m/z$ : Calcd. for  $C_{31}H_{36}N_2O_{12}S_2$ : 692.2. Found ( $M-H_2O+H^+$ ): 675.2.



Compound **22a\***:  $^1H$  NMR (300 MHz,  $CDCl_3$ ):  $\delta$  6.50 (s, 1H), 6.02 (dd, 2H), 5.67 (s, 1H), 4.73 (bp, 1H), 4.71 (s, 1H), 4.48-4.38 (m, 4H), 4.12-4.10 (m, 1H), 3.80 (s, 3H), 3.61-3.59 (m, 1H), 3.22-3.18 (m, 1H), 2.89-2.80 (m, 1H), 2.70 (d, 1H), 2.33-1.86 (m, 2H), 2.33 (s, 3H), 2.30 (s, 3H), 2.12 (s, 3H), 2.01 (s, 3H), 1.94 (s, 3H); ESI-MS  $m/z$ : Calcd. for  $C_{32}H_{36}N_2O_{11}S$ : 656.2. Found ( $M-H_2O+H^+$ ): 639.2.

### Example 11

**Method K:** A solution of **7** in  $CH_2Cl_2/H_2O/TFA$  2:1:4 (0.013M) was stirred for 15 min at RT. Then the reaction was diluted with  $CH_2Cl_2$ , neutralized with a saturated solution of  $NaHCO_3$  and  $Na_2CO_3$  and extracted with  $CH_2Cl_2$ . The organic layer was dried with  $Na_2SO_4$ . Flash chromatography ( $CH_2Cl_2/MeOH$ ) gives pure **2p**.

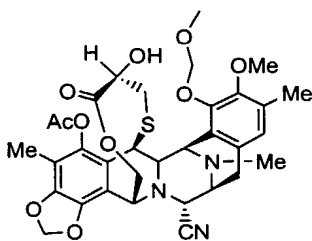


Compound **2p**:  $^1H$  NMR (300 MHz,  $CDCl_3$ ):  $\delta$  6.93 (bp, 1H), 6.72 (s, 1H), 6.05 (dd, 2H), 5.15 (dd, 2H), 5.03 (d, 1H), 4.66-4.63 (m, 1H), 4.54 (bp, 1H), 4.35 (d, 1H), 4.32 (s, 1H), 4.23 (d, 1H), 4.17 (dd, 1H), 3.75 (s, 3H), 3.56 (s, 3H), 3.49-3.42 (m, 2H), 3.04 (d, 1H), 2.93-2.90 (m, 2H), 2.28-2.03 (m, 3H), 2.28 (s, 6H), 2.14 (s, 3H), 2.03 (s, 3H), 0.97 (d, 3H), 0.77 (d, 3H); ESI-MS  $m/z$ : Calcd. for  $C_{38}H_{47}N_5O_{10}S$ : 765.3. Found ( $M+H^+$ ): 766.3.

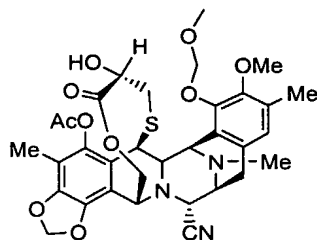


## Example 12

**Method L:** To a solution of **10** in CH<sub>3</sub>CN (0.03M) were added 2 equiv. of NaCNBH<sub>3</sub> and 4 equiv. of AcOH. After 4 h the reaction was diluted with CH<sub>2</sub>Cl<sub>2</sub>; neutralized with a saturated solution of NaHCO<sub>3</sub> and extracted with CH<sub>2</sub>Cl<sub>2</sub>. The organic layer was dried with Na<sub>2</sub>SO<sub>4</sub>. Flash chromatography (Hex/EtOAc 2:1) gives pure compounds.



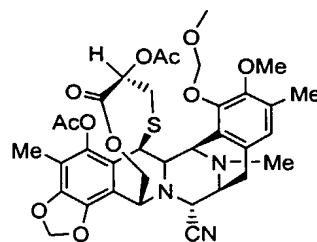
**Compound 11:** <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 6.77 (s, 1H), 6.03 (dd, 2H), 5.17 (dd, 2H), 5.04 (d, 1H), 4.53 (bp, 1H), 4.34 (d, 1H), 4.27 (s, 1H), 4.20 (d, 1H), 4.19 (dd, 1H), 4.01 (bddd, 1H), 3.77 (s, 3H), 3.57 (s, 3H), 3.55-3.39 (m, 2H), 2.94-2.91 (m, 2H), 2.30-1.98 (m, 2H), 2.30 (s, 3H), 2.25 (s, 3H), 2.20 (s, 3H), 2.03 (s, 3H); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 172.6, 168.6, 149.6, 148.3, 145.7, 141.0, 140.4, 131.6, 130.3, 124.8, 124.7, 120.5, 118.0, 113.3, 102.0, 99.1, 69.8, 61.4, 60.4, 59.6, 59.1, 59.0, 57.4, 54.9, 54.6, 41.4, 41.4, 35.0, 23.8, 20.3, 15.7, 9.6. ESI-MS m/z: Calcd. for C<sub>33</sub>H<sub>37</sub>N<sub>3</sub>O<sub>10</sub>S: 667.3. Found (M+H<sup>+</sup>): 668.2.



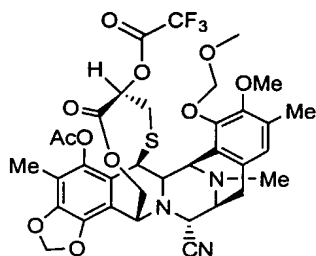
**Compound 12\*:** <sup>1</sup>H NMR (300 MHz, 45°C, CDCl<sub>3</sub>): δ 6.70 (s, 1H), 6.04 (dd, 2H), 5.17 (dd, 2H), 4.88 (bd, 1H), 4.49 (bs, 1H), 4.33 (bd, 1H), 4.27-4.24 (m, 1H), 4.24 (s, 1H), 4.08 (d, 1H), 3.79 (s, 3H), 3.60-3.55 (m, 2H), 3.56 (s, 3H), 3.42-3.39 (m, 1H), 3.00-2.91 (m, 1H), 2.76 (d, 1H), 2.50-2.42 (m, 1H), 2.32 (s, 3H), 2.27 (s, 3H), 2.16 (s, 3H), 2.02 (s, 3H), 1.66 (dd, 1H); ESI-MS m/z: Calcd. for C<sub>33</sub>H<sub>37</sub>N<sub>3</sub>O<sub>10</sub>S: 667.3. Found (M+H<sup>+</sup>): 668.2.

## Example 13

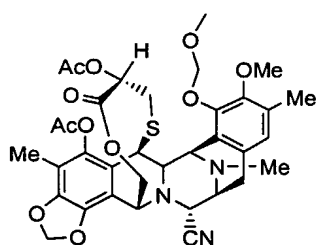
**Method M:** To a solution of 1 equiv. of **11** for **13a-b** or **12\*** for **14a\*** in CH<sub>2</sub>Cl<sub>2</sub> (0.1M) under Argon were added 30 equiv. of pyr. Then the reaction was cold to 0°C and 20 equiv. of the anhydride and 5 equiv. of DMAP were added. After 5 min the reaction was warmed to room temperature and stirred for 24 h. After this time it was quenched with NaCl, extracted with CH<sub>2</sub>Cl<sub>2</sub> and the organic layers dried with Na<sub>2</sub>SO<sub>4</sub>. Flash chromatography gives pure compounds.



**Compound 13a (using Ac<sub>2</sub>O):** <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 6.70 (s, 1H), 6.04 (dd, 2H), 5.17 (dd, 2H), 5.02-4.99 (m, 2H), 4.56 (bp, 1H), 4.34 (dd, 1H), 4.27 (s, 1H), 4.18 (d, 1H), 4.14 (dd, 1H), 3.78 (s, 3H), 3.57 (s, 3H), 3.46-3.39 (m, 2H), 2.90-2.87 (m, 2H), 2.30-1.96 (m, 2H), 2.30 (s, 3H), 2.25 (s, 3H), 2.17 (s, 3H), 2.03 (s, 3H), 1.99 (s, 3H); <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 169.7, 167.1, 148.9, 148.2, 145.9, 141.2, 140.6, 130.7, 130.7, 125.3, 124.6, 120.8, 118.1, 113.5, 113.1, 102.0, 99.2, 71.6, 61.4, 60.0, 59.9, 59.2, 58.7, 57.4, 55.0, 54.6, 41.5, 31.6, 23.9, 20.3, 20.2, 15.8, 9.6. ESI-MS m/z: Calcd. for C<sub>35</sub>H<sub>39</sub>N<sub>3</sub>O<sub>11</sub>S: 709.6. Found (M+H<sup>+</sup>): 710.2.

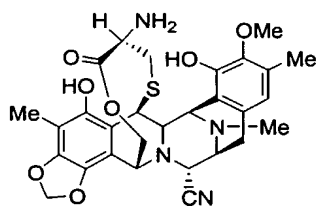


Compound **13b** (using  $(F_3CCO)_2O$ ):  $^1H$  NMR (300 MHz,  $CDCl_3$ ):  $\delta$  6.67 (s, 1H), 6.04 (dd, 2H), 5.17 (dd, 2H), 5.10 (bt, 1H), 5.02 (d, 1H), 4.62 (bp, 1H), 4.34-4.32 (m, 2H), 4.19-4.15 (m, 2H), 3.76 (s, 3H), 3.56 (s, 3H), 3.47 (d, 1H), 3.44-3.41 (m, 1H), 2.94-2.77 (m, 2H), 2.47-2.37 (m, 1H), 2.31 (s, 3H), 2.23 (s, 3H), 2.17 (s, 3H), 2.07-2.04 (m, 1H), 2.04 (s, 3H);  $^{13}C$  NMR (75 MHz,  $CDCl_3$ ):  $\delta$  168.7, 164.9, 148.7, 148.2, 145.9, 141.2, 140.7, 131.6, 130.3, 125.7, 124.0, 120.6, 118.0, 113.3, 102.1, 99.2, 74.7, 61.4, 60.5, 60.0, 59.1, 59.2, 58.7, 57.4, 54.9, 54.6, 41.7, 41.5, 31.1, 23.9, 20.2, 15.5, 9.6. ESI-MS  $m/z$ : Calcd. for  $C_{35}H_{36}F_3N_3O_{11}S$ : 763.2. Found ( $M+H^+$ ): 764.2.

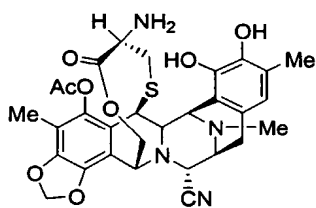


Compound **14a\*** (using  $Ac_2O$ ):  $^1H$  NMR (300 MHz,  $CDCl_3$ ):  $\delta$  6.71 (s, 1H), 6.05 (dd, 2H), 5.16 (dd, 2H), 4.65-4.10 (m, 7H), 3.79 (s, 3H), 3.57-3.54 (m, 1H), 3.56 (s, 3H), 3.43-3.40 (m, 1H), 2.97-2.88 (m, 1H), 2.78 (d, 1H), 2.33-1.82 (m, 2H), 2.32 (s, 3H), 2.27 (s, 3H), 2.15 (s, 3H), 2.03 (s, 3H), 1.94 (s, 3H); ESI-MS  $m/z$ : Calcd. for  $C_{35}H_{39}N_3O_{11}S$ : 709.6. Found ( $M+H^+$ ): 710.7.

#### COMPOUNDS 23 AND 24:

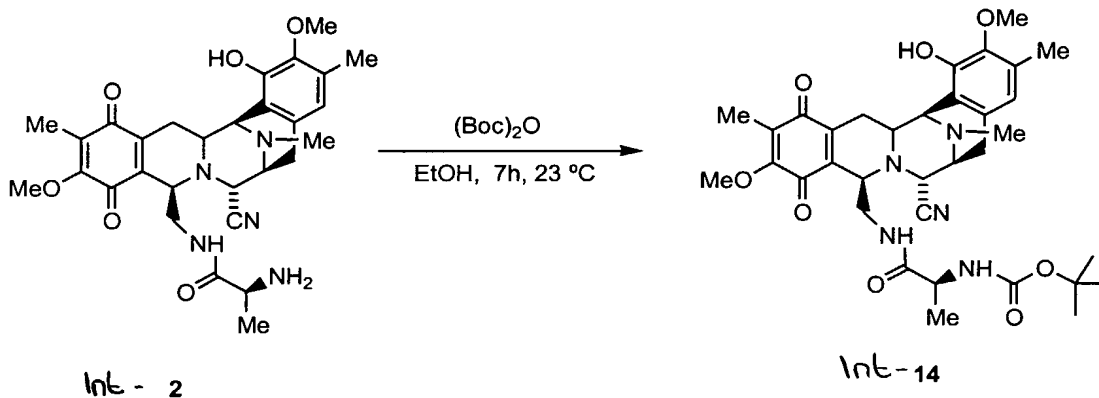


Compound **23**:  $^1H$  NMR (300 MHz,  $CDCl_3$ ):  $\delta$  6.52 (s, 1H), 5.95 (dd, 2H), 4.97 (d, 1H), 4.42 (d, 1H), 4.28 (bs, 2H), 4.15 (d, 1H), 4.05 (dd, 1H), 3.78 (s, 3H), 3.51-3.50 (m, 1H), 3.40-3.39 (m, 1H), 3.27 (t, 1H), 2.91-2.89 (m, 2H), 2.38-2.36 (m, 2H), 2.28 (s, 3H), 2.17 (s, 3H), 2.14 (s, 3H);  $^{13}C$  NMR (75 MHz,  $CDCl_3$ ):  $\delta$  173.9, 148.1, 146.2, 146.1, 142.8, 136.2, 130.4, 129.5, 120.8, 118.2, 112.7, 112.7, 107.7, 101.3, 61.1, 60.9, 60.4, 59.4, 58.8, 54.6, 54.6, 53.5, 43.3, 41.4, 33.0, 23.9, 15.7, 8.7; ESI-MS  $m/z$ : Calcd. for  $C_{29}H_{32}N_4O_7S$ : 580.2. Found ( $M+H^+$ ): 581.3.



Compound **24**:  $^1H$  NMR (300 MHz,  $CDCl_3$ ):  $\delta$  6.40 (s, 1H), 6.02 (d, 2H), 5.00 (d, 1H), 4.46 (bp, 1H), 4.24 (s, 1H), 4.21-4.14 (m, 3H), 3.39-3.37 (m, 2H), 3.29 (t, 1H), 2.93-2.78 (m, 2H), 2.31-2.03 (m, 2H), 2.31 (s, 3H), 2.25 (bs, 3H), 2.14 (s, 6H);  $^{13}C$  NMR (75 MHz,  $CDCl_3$ ):  $\delta$  173.6, 168.9, 145.6, 145.3, 140.9, 140.2, 139.3, 126.1, 123.9, 120.2, 119.7, 118.1, 117.7, 113.6, 113.3, 101.9, 61.3, 60.3, 59.1, 59.1, 54.7, 54.6, 53.3, 41.9, 41.4, 33.0, 23.5, 20.5, 16.8, 9.6; ESI-MS  $m/z$ : Calcd. for  $C_{30}H_{32}N_4O_8S$ : 608.2. Found ( $M+H^+$ ): 609.3.

## Example 14

Compound **Int-14**

To a solution of **Int-2** (21.53 g, 39.17 ml) in ethanol (200 ml), *tert*-butoxycarbonyl anhydride (7.7 g, 35.25 ml) was added and the mixture was stirred for 7 h at 23 °C. Then, the reaction was concentrated *in vacuo* and the residue was purified by flash column chromatography (SiO<sub>2</sub>, hexane:ethyl acetate 6:4) to give **Int-14** (20.6 g, 81 %) as a yellow solid.

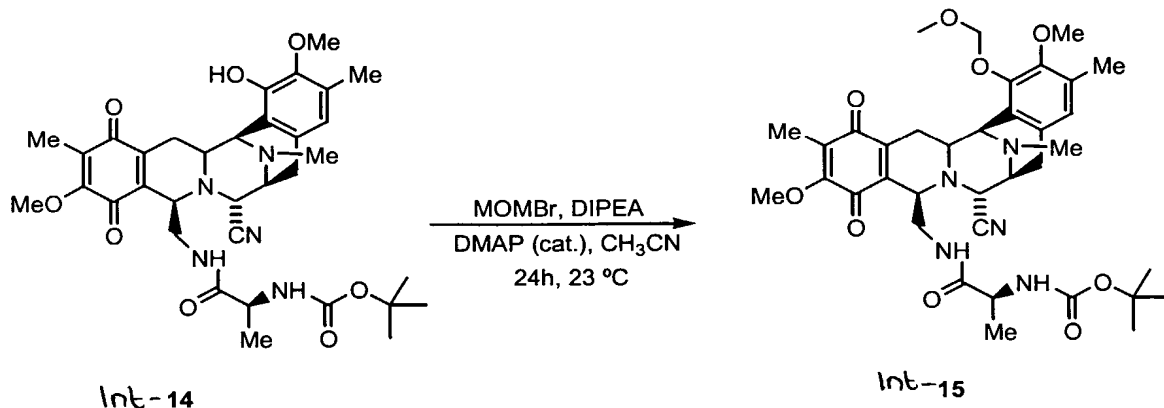
R<sub>f</sub>: 0.52 (ethyl acetate:CHCl<sub>3</sub> 5:2).

<sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 6.49 (s, 1H), 6.32 (bs, 1H), 5.26 (bs, 1H), 4.60 (bs, 1H), 4.14 (d, *J* = 2.4 Hz, 1H), 4.05 (d, *J* = 2.4 Hz, 1H), 3.94 (s, 3H), 3.81 (d, *J* = 4.8 Hz, 1H), 3.7 (s, 3H), 3.34 (br d, *J* = 7.2 Hz, 1H), 3.18-3.00 (m, 5H), 2.44 (d, *J* = 18.3 Hz, 1H), 2.29 (s, 3H), 2.24 (s, 3H), 1.82 (s, 3H), 1.80-1.65 (m, 1H), 1.48 (s, 9H), 0.86 (d, *J* = 5.7 Hz, 3H)

<sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 185.5, 180.8, 172.7, 155.9, 154.5, 147.3, 143.3, 141.5, 135.3, 130.4, 129.2, 127.5, 120.2, 117.4, 116.9, 80.2, 60.7, 60.3, 58.5, 55.9, 55.8, 54.9, 54.4, 50.0, 41.6, 40.3, 28.0, 25.3, 24.0, 18.1, 15.6, 8.5.

ESI-MS *m/z*: Calcd. for C<sub>34</sub>H<sub>43</sub>N<sub>5</sub>O<sub>8</sub>: 649.7. Found (M+H)<sup>+</sup>: 650.3.

## Example 15

Compound **Int-15**

To a stirred solution of **Int-14** (20.6 g, 31.75 ml) in  $\text{CH}_3\text{CN}$  (159 ml), diisopropylethylamine (82.96 ml, 476.2 ml), methoxymethylene bromide (25.9 ml, 317.5 ml) and dimethylaminopyridine (155 mg, 1.27 ml) were added at 0 °C. The mixture was stirred at 23 °C for 24h. The reaction was quenched at 0 °C with aqueous 0.1N HCl (750 ml) (pH = 5), and extracted with  $\text{CH}_2\text{Cl}_2$  (2 x 400 ml). The organic phase was dried (sodium sulphate) and concentrated *in vacuo*. The residue was purified by flash column chromatography ( $\text{SiO}_2$ , gradient hexane:ethyl acetate 4:1 to hexane:ethyl acetate 3:2) to give **Int-15** (17.6 g, 83 %) as a yellow solid.

Rf: 0.38 (hexane:ethyl acetate 3:7).

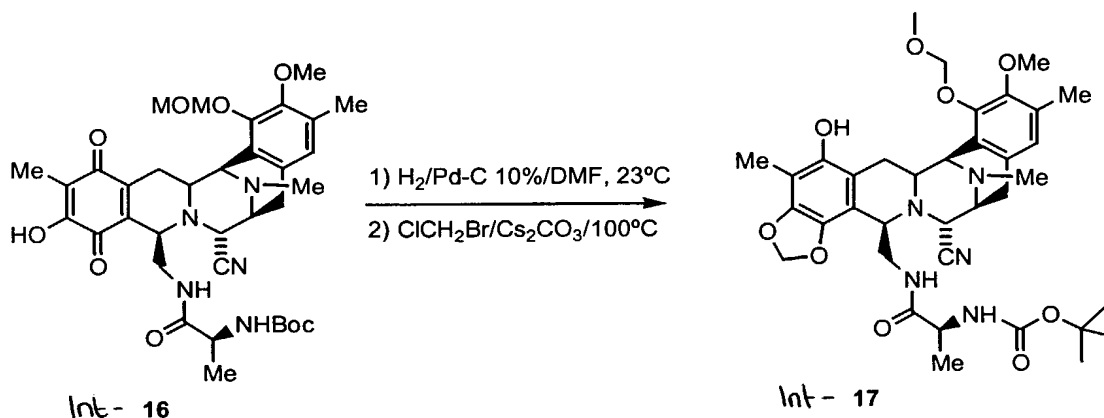
$^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.73 (s, 1H), 5.35 (bs, 1H), 5.13 (s, 2H), 4.50 (bs, 1H), 4.25 (d,  $J$  = 2.7 Hz, 1H), 4.03 (d,  $J$  = 2.7 Hz, 1H), 3.97 (s, 3H), 3.84 (bs, 1H), 3.82-3.65 (m, 1H), 3.69 (s, 3H), 3.56 (s, 3H), 3.39-3.37 (m, 1H), 3.20-3.00 (m, 5H), 2.46 (d,  $J$  = 18 Hz, 1H), 2.33 (s, 3H), 2.23 (s, 3H), 1.85 (s, 3H), 1.73-1.63 (m, 1H), 1.29 (s, 9H), 0.93 (d,  $J$  = 5.1 Hz, 3H)

$^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  185.4, 180.9, 172.4, 155.9, 154.5, 149.0, 148.4, 141.6, 135.1, 131.0, 129.9, 127.6, 124.4, 123.7, 117.3, 99.1, 79.3, 60.7, 59.7, 58.4, 57.5, 56.2, 55.9, 55.0, 54.2, 50.0, 41.5, 39.9, 28.0, 25.2, 24.0, 18.1, 15.6, 8.5.

ESI-MS  $m/z$ : Calcd. for  $\text{C}_{36}\text{H}_{47}\text{N}_5\text{O}_9$ : 693.8. Found  $(\text{M}+\text{H})^+$ : 694.3.



## Example 17

Compound **Int-17**

To a degassed solution of compound **Int-16** (1.8 g, 2.64 ml) in DMF (221 ml) 10 % Pd/C (360 mg) was added and stirred under  $\text{H}_2$  (atmospheric pressure) for 45 min. The reaction was filtered through celite under argon, to a flask containing anhydrous  $\text{Cs}_2\text{CO}_3$  (2.58 g, 7.92 ml). Then, bromochloromethane (3.40 ml 52.8 ml), was added and the tube was sealed and stirred at  $100^\circ\text{C}$  for 2h. The reaction was cooled, filtered through a pad of celite and washed with  $\text{CH}_2\text{Cl}_2$ . The organic layer was concentrated and dried (sodium sulphate) to afford **Int-17** as a brown oil that was used in the next step with no further purification.

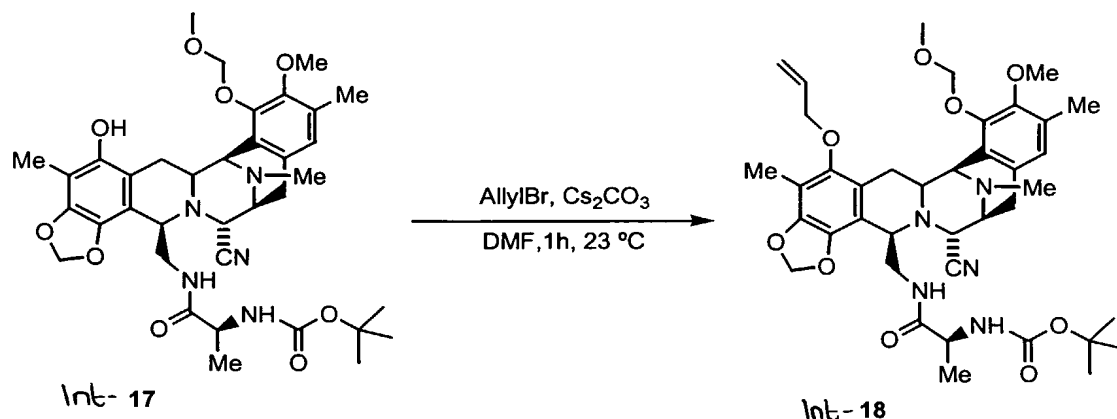
Rf: 0.36 (hexane:ethyl acetate 1:5,  $\text{SiO}_2$ ).

$^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.68 (s, 1H), 6.05 (bs, 1H), 5.90 (s, 1H), 5.79 (s, 1H), 5.40 (bs, 1H), 5.31-5.24 (m, 2H), 4.67 (d,  $J=8.1$  Hz, 1H), 4.19 (d,  $J=2.7$  Hz, 1H), 4.07 (bs, 1H), 4.01 (bs, 1H), 3.70 (s, 3H), 3.67 (s, 3H), 3.64-2.96 (m, 5H), 2.65 (d,  $J=18.3$  Hz, 1H), 2.33 (s, 3H), 2.21 (s, 3H), 2.04 (s, 3H), 2.01-1.95 (m, 1H), 1.28 (s, 9H), 0.87 (d,  $J=6.3$  Hz, 3H)

$^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  172.1, 162.6, 154.9, 149.1, 145.7, 135.9, 130.8, 130.7, 125.1, 123.1, 117.8, 100.8, 99.8, 76.6, 59.8, 59.2, 57.7, 57.0, 56.7, 55.8, 55.2, 49.5, 41.6, 40.1, 36.5, 31.9, 31.6, 29.7, 28.2, 26.3, 25.0, 22.6, 18.2, 15.8, 14.1, 8.8.

ESI-MS  $m/z$ : Calcd. for  $\text{C}_{36}\text{H}_{47}\text{N}_5\text{O}_9$ : 693.34. Found  $(\text{M}+\text{H})^+$ : 694.3.

## Example 18

Compound **Int-18**

To a flask containing a solution of **Int-17** (1.83 g, 2.65 ml) in DMF (13 ml),  $\text{Cs}_2\text{CO}_3$  (2.6 g, 7.97 ml), and allyl bromide (1.15 ml, 13.28 ml) were added at 0° C. The resulting mixture was stirred at 23 °C for 1h. The reaction was filtered through a pad of celite and washed with  $\text{CH}_2\text{Cl}_2$ . The organic layer was dried and concentrated (sodium sulphate). The residue was purified by flash column chromatography ( $\text{SiO}_2$ ,  $\text{CHCl}_3$ :ethyl acetate 1:4) to afford **Int-18** (1.08 mg, 56 %) as a white solid.

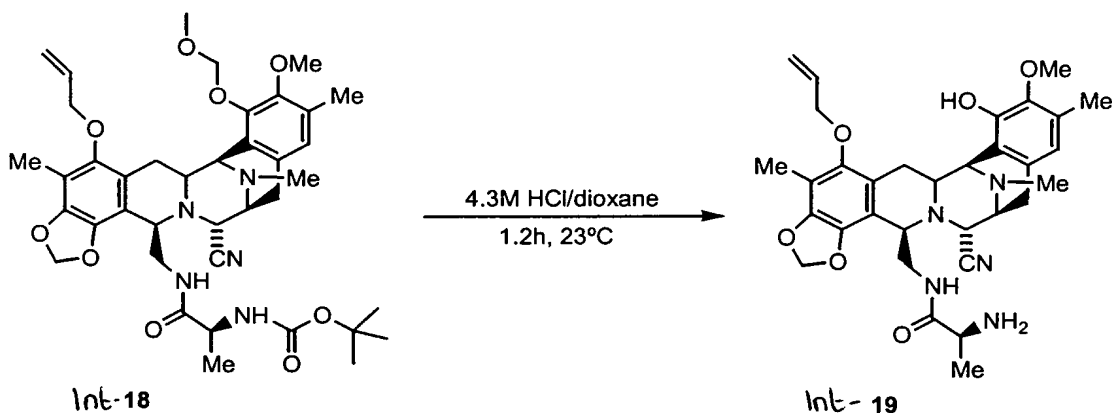
Rf: 0.36 ( $\text{CHCl}_3$ :ethyl acetate 1:3).

$^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.70 (s, 1H), 6.27-6.02 (m, 1H), 5.94 (s, 1H), 5.83 (s, 1H), 5.37 (dd,  $J_1 = 1.01$  Hz,  $J_2 = 16.8$  Hz, 1H), 5.40 (bs, 1H), 5.25 (dd,  $J_1 = 1.0$  Hz,  $J_2 = 10.5$  Hz, 1H), 5.10 (s, 2H), 4.91 (bs, 1H), 4.25-4.22 (m, 1H), 4.21 (d,  $J = 2.4$  Hz, 1H), 4.14-4.10 (m, 1H), 4.08 (d,  $J = 2.4$  Hz, 1H), 4.00 (bs, 1H), 3.70 (s, 3H), 3.59 (s, 3H), 3.56-3.35 (m, 2H), 3.26-3.20 (m, 2H), 3.05-2.96 (dd,  $J_1 = 8.1$  Hz,  $J_2 = 18$  Hz, 1H), 2.63 (d,  $J = 18$  Hz, 1H), 2.30 (s, 3H), 2.21 (s, 3H), 2.09 (s, 3H), 1.91-1.80 (m, 1H), 1.24 (s, 9H), 0.94 (d,  $J = 6.6$  Hz, 3H)

$^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  172.0, 154.8, 148.8, 148.6, 148.4, 144.4, 138.8, 133.7, 130.9, 130.3, 125.1, 124.0, 120.9, 117.8, 117.4, 112.8, 112.6, 101.1, 99.2, 73.9, 59.7, 59.3, 57.7, 56.9, 56.8, 56.2, 55.2, 40.1, 34.6, 31.5, 28.1, 26.4, 25.1, 22.6, 18.5, 15.7, 14.0, 9.2.

ESI-MS m/z: Calcd. for  $\text{C}_{39}\text{H}_{51}\text{N}_5\text{O}_9$ : 733.4. Found  $(\text{M}+\text{H})^+$ : 734.4.

## Example 19

Compound **Int-19**

To a solution of **Int-18** (0.1 g, 0.137 ml) in dioxane (2 ml), 4.2M HCl/dioxane (1.46 ml) was added and the mixture was stirred for 1.2h at 23 °C. The reaction was quenched at 0 °C with sat. Aqueous sodium bicarbonate (60 ml) and extracted with ethyl acetate (2x70 ml). The organic layers were dried (sodium sulphate) and concentrated *in vacuo* to afford **Int-19** (267 mg, 95 %) as a white solid that was used in subsequent reactions with no further purification.

Rf: 0.17 (ethyl acetate:methanol 10:1, SiO<sub>2</sub>)

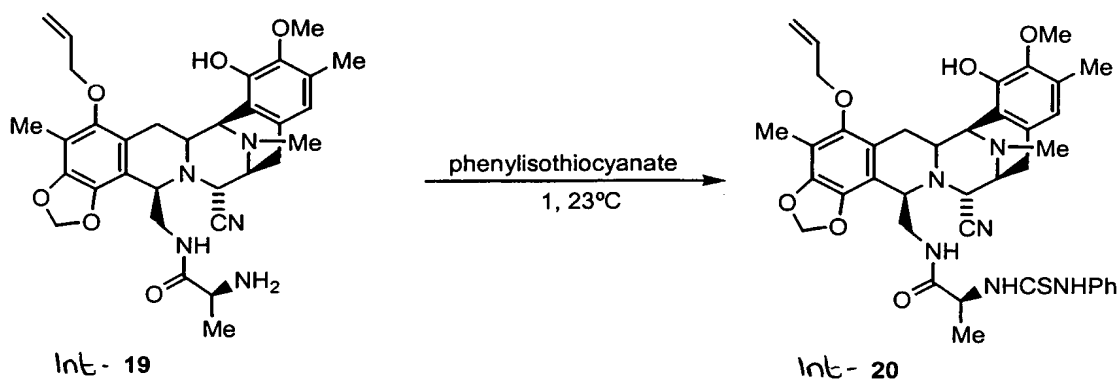
<sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 6.49 (s, 1H), 6.12-6.00 (m, 1H), 5.94 (s, 1H), 5.86 (s, 1H), 5.34 (dd, *J* = 1.0 Hz, *J* = 17.4 Hz, 1H), 5.25 (dd, *J* = 1.0 Hz, *J* = 10.2 Hz, 1H), 4.18-3.76 (m, 5H), 3.74 (s, 3H), 3.71-3.59 (m, 1H), 3.36-3.20 (m, 4H), 3.01-2.90 (m, 1H), 2.60 (d, *J* = 18.0 Hz, 1H), 2.29 (s, 3H), 2.24 (s, 3H), 2.11 (s, 3H), 1.97-1.86 (m, 1H), 0.93 (d, *J* = 8.7 Hz, 3H)

<sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 175.5, 148.4, 146.7, 144.4, 142.4, 138.9, 133.7, 131.3, 128.3, 120.8, 117.9, 117.4, 113.8, 112.4, 101.1, 74.2, 60.5, 59.1, 56.5, 56.1, 56.3, 56.0, 55.0, 50.5, 41.6, 39.5, 29.5, 26.4, 24.9, 21.1, 15.5, 9.33.

ESI-MS *m/z*: Calcd. for C<sub>32</sub>H<sub>39</sub>N<sub>5</sub>O<sub>6</sub>: 589. Found (M+H)<sup>+</sup>: 590.



## Example 20

Compound **Int-20**

To a solution of **Int-19** (250 mg, 0.42 ml) in  $\text{CH}_2\text{Cl}_2$  (1.5 ml), phenyl isothiocyanate (0.3 ml, 2.51 ml) was added and the mixture was stirred at  $23^{\circ}\text{C}$  for 1h. The reaction was concentrated *in vacuo* and the residue was purified by flash column chromatography ( $\text{SiO}_2$ , gradient Hexane to 5:1 hexane:ethyl acetate) to afford **Int-20** (270 mg, 87 %) as a white solid.

Rf: 0.56 ( $\text{CHCl}_3$ :ethyl acetate 1:4).

$^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  8.00 (bs, 1H), 7.45-6.97 (m, 4H), 6.10 (s, 1H), 6.08-6.00 (m, 1H), 5.92 (s, 1H), 5.89 (s, 1H), 5.82 (s, 1H), 5.40 (dd,  $J = 1.5$  Hz,  $J = 17.1$  Hz, 1H), 3.38 (bs, 1H), 5.23 (dd,  $J = 1.5$  Hz,  $J = 10.5$  Hz, 1H), 4.42-4.36 (m, 1H), 4.19-4.03 (m, 5H), 3.71 (s, 3H), 3.68-3.17 (m, 4H), 2.90 (dd,  $J = 7.8$  Hz,  $J = 18.3$  Hz, 1H), 2.57 (d,  $J = 18.3$  Hz, 1H), 2.25 (s, 3H), 2.12 (s, 3H), 2.10 (s, 3H), 1.90 (dd,  $J = 12.3$  Hz,  $J = 16.5$  Hz, 1H), 0.81 (d,  $J = 6.9$  Hz, 3H).

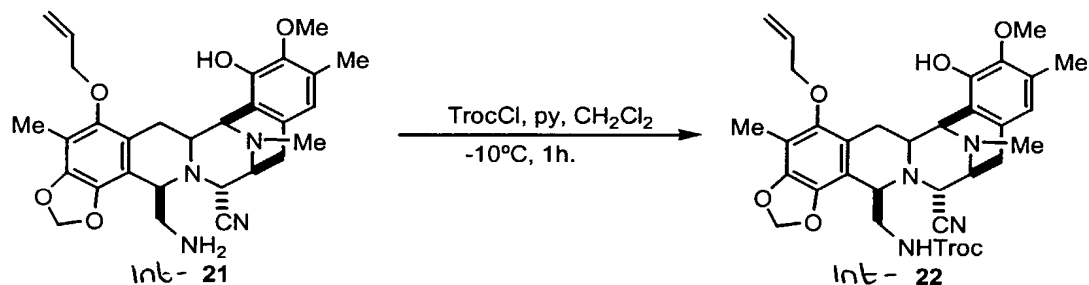
$^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  178.4, 171.6, 148.6, 146.8, 144.3, 142.7, 138.7, 136.2, 133.6, 130.7, 129.8, 126.6, 124.2, 124.1, 120.9, 120.5, 117.7, 117.4, 116.7, 112.6, 112.5, 101.0, 74.0, 60.6, 59.0, 57.0, 56.2, 56.1, 55.0, 53.3, 41.4, 39.7, 26.3, 24.8, 18.3, 15.5, 9.2.

ESI-MS  $m/z$ : Calcd. for  $\text{C}_{39}\text{H}_{44}\text{N}_6\text{O}_6\text{S}$ : 724.8 Found ( $\text{M}+\text{H}$ ) $^+$ : 725.3.



### Example 22

### Compound Int-22



To a solution of **Int-21** (0.64 g, 1.22 ml) in CH<sub>2</sub>Cl<sub>2</sub> (6.13 ml), pyridine (0.104 ml, 1.28 ml) and 2,2,2-trichloroethyl chloroformate (0.177 ml, 1.28 ml) were added at -10 °C. The mixture was stirred at this temperature for 1h and then, the reaction was quenched by addition of 0.1N HCl (10 ml) and extracted with CH<sub>2</sub>Cl<sub>2</sub> (2 x 10 ml). The organic layer was dried over sodium sulphate and concentrated *in vacuo*. The residue was purified by flash column chromatography (SiO<sub>2</sub>, (hexane:ethyl acetate 1:2) to afford **Int-22** (0.84 g, 98%) as a white foam solid.

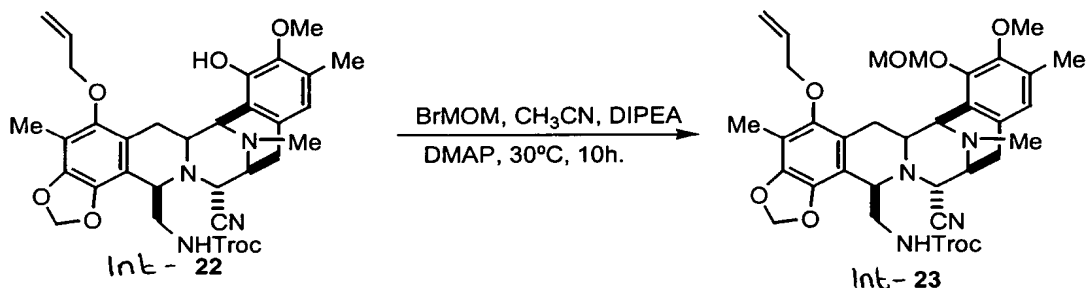
Rf: 0.57 (ethyl acetate:methanol 5:1).

<sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 6.50 (s, 1H), 6.10-6.00 (m, 1H), 6.94 (d, *J*= 1.5 Hz, 1H), 5.87 (d, *J*= 1.5 Hz, 1H), 5.73 (bs, 1H), 5.37 (dq, *J*<sub>1</sub>= 1.5 Hz, *J*<sub>2</sub>= 17.1 Hz, 1H), 5.26 (dq, *J*<sub>1</sub>= 1.8 Hz, *J*<sub>2</sub>= 10.2 Hz, 1H), 4.60 (d, *J*= 12 Hz, 1H), 4.22-4.10 (m, 4H), 4.19 (d, *J*= 12 Hz, 1H), 4.02 (m, 2H), 3.75 (s, 3H), 3.37-3.18 (m, 5H), 3.04 (dd, *J*<sub>1</sub>= 8.1 Hz, *J*<sub>2</sub>= 18 Hz, 1H), 2.63 (d, *J*= 18 Hz, 1H), 2.31 (s, 3H), 2.26 (s, 3H), 2.11 (s, 3H), 1.85 (dd, *J*<sub>1</sub>= 12.3 Hz, *J*<sub>2</sub>= 15.9 Hz, 1H).

<sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>) δ 154.3, 148.5, 146.7, 144.5, 142.8, 139.0, 133.8, 130.7, 128.7, 121.3, 120.8, 117.8, 117.7, 116.8, 112.7, 101.2, 77.2, 74.3, 60.7, 59.9, 57.0, 56.4, 55.3, 43.3, 41.7, 31.6, 26.4, 25.3, 22.6, 15.9, 14.1, 9.4.

ESI-MS  $m/z$ : Calcd. for  $C_{32}H_{35}Cl_3N_4O_7$ : 694.17. Found  $(M+H)^+$ : 695.2.

## Example 23

Compound **Int-23**

To a solution of **Int-22** (0.32 g, 0.46 ml) in  $\text{CH}_3\text{CN}$  (2.33 ml), diisopropylethylamine (1.62 ml, 9.34 ml), bromomethyl methyl ether (0.57 ml, 7.0 ml) and dimethylaminopyridine (6 mg, 0.046 ml) were added at 0 °C. The mixture was heated at 30 °C for 10h. Then, the reaction was diluted with dichloromethane (30 ml) and poured in an aqueous solution of HCl at pH = 5 (10 ml). The organic layer was dried over sodium sulphate and the solvent was eliminated under reduced pressure to give a residue which was purified by flash column chromatography ( $\text{SiO}_2$ , hexane:ethyl acetate 2:1) to afford **Int-23** (0.304 g, 88%) as a white foam solid.

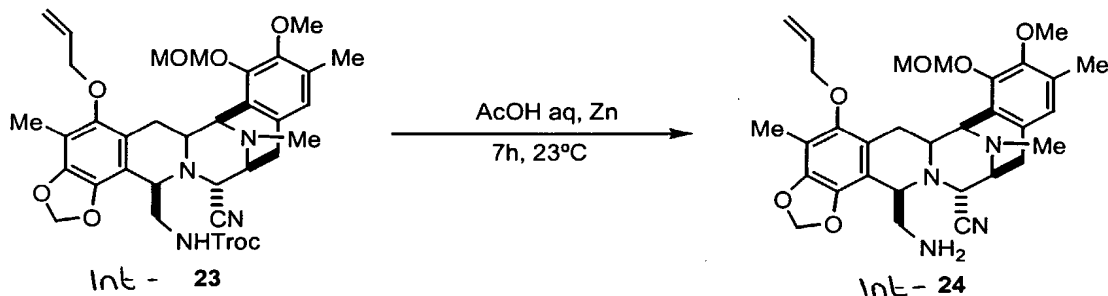
Rf: 0.62 (hexane:ethyl acetate 1:3).

$^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.73 (s, 1H), 6.10 (m, 1H), 5.94 (d,  $J = 1.5$  Hz, 1H), 5.88 (d,  $J = 1.5$  Hz, 1H), 5.39 (dq,  $J_1 = 1.5$  Hz,  $J_2 = 17.1$  Hz, 1H), 5.26 (dq,  $J_1 = 1.8$  Hz,  $J_2 = 10.2$  Hz, 1H), 5.12 (s, 2H), 4.61 (d,  $J = 12$  Hz, 1H), 4.55 (t,  $J = 6.6$  Hz, 1H), 4.25 (d,  $J = 12$  Hz, 1H), 4.22-4.11 (m, 4H), 4.03 (m, 2H), 3.72 (s, 3H), 3.58 (s, 3H), 3.38-3.21 (m, 5H), 3.05 (dd,  $J_1 = 8.1$  Hz,  $J_2 = 18$  Hz, 1H), 2.65 (d,  $J = 18$  Hz, 1H), 2.32 (s, 3H), 2.23 (s, 3H), 2.12 (s, 3H), 1.79 (dd,  $J_1 = 12.3$  Hz,  $J_2 = 15.9$  Hz, 1H);

$^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ )  $\delta$  154.3, 148.6, 148.4, 144.5, 139.0, 133.6, 130.6, 130.1, 125.07, 124.7, 124.0, 121.1, 117.7, 112.6, 101.2, 99.2, 77.2, 74.4, 74.1, 59.8, 59.8, 57.7, 57.0, 56.8, 56.68, 55.3, 43.2, 41.5, 26.4, 25.2, 15.9, 9.3.

ESI-MS  $m/z$ : Calcd. for  $\text{C}_{34}\text{H}_{39}\text{Cl}_3\text{N}_4\text{O}_8$ : 738.20. Found  $(\text{M}+\text{H})^+$ : 739.0.

## Example 24

Compound **Int-24**

To a suspension of **Int-23** (0.304 g, 0.41 ml) in 90% aqueous acetic acid (4 ml), powder zinc (0.2 g, 6.17 ml) was added and the reaction was stirred for 7 hour at 23 °C. The mixture was filtered through a pad of celite which was washed with CH<sub>2</sub>Cl<sub>2</sub>. The organic layer was washed with an aqueous sat. solution of sodium bicarbonate (pH = 9) (15 ml) and dried over sodium sulphate. The solvent was eliminated under reduced pressure to give **Int-24** (0.191 g, 83%) as a white solid.

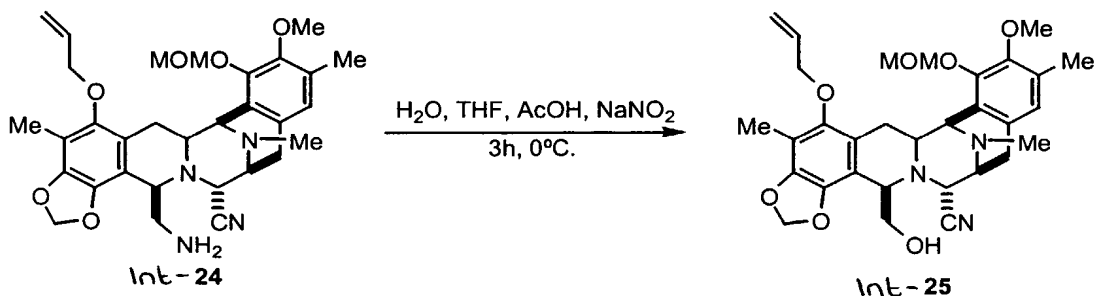
Rf: 0.3 (ethyl acetate:methanol 5:1).

<sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>): δ 6.68 (s, 1H), 6.09 (m, 1H), 5.90 (d, *J* = 1.5 Hz, 1H), 5.83 (d, *J* = 1.5 Hz, 1H), 5.39 (dq, *J*<sub>1</sub> = 1.5 Hz, *J*<sub>2</sub> = 17.1 Hz, 1H), 5.25 (dq, *J*<sub>1</sub> = 1.5 Hz, *J*<sub>2</sub> = 10.2 Hz, 1H), 5.10 (s, 2H), 4.22-4.09 (m, 3H), 3.98 (d, *J* = 2.4 Hz, 1H), 3.89 (m, 1H), 3.69 (s, 3H), 3.57 (s, 3H), 3.37-3.17 (m, 3H), 3.07 (dd, *J*<sub>1</sub> = 8.1 Hz, *J*<sub>2</sub> = 18 Hz, 1H), 2.71 (m, 2H), 2.48 (d, *J* = 18 Hz, 1H), 2.33 (s, 3H), 2.19 (s, 3H), 2.17 (s, 3H), 1.80 (dd, *J*<sub>1</sub> = 12.3 Hz, *J*<sub>2</sub> = 15.9 Hz, 1H)

<sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>): δ 148.5, 148.2, 144.3, 138.7, 133.7, 130.7, 129.9, 125.0, 123.9, 121.3, 117.9, 117.5, 113.6, 112.0, 101.0, 99.2, 74.0, 59.8, 59.7, 58.8, 57.6, 57.0, 56.2, 55.2, 44.2, 41.5, 31.5, 26.4, 25.6, 22.5, 16.7, 14.0, 9.2.

ESI-MS *m/z*: Calcd. for C<sub>31</sub>H<sub>38</sub>N<sub>4</sub>O<sub>6</sub>: 562.66. Found (M+H)<sup>+</sup>: 563.1.

## Example 25

Compound **Int-25**

To a solution of **Int-24** (20 mg, 0.035 ml), in  $\text{H}_2\text{O}$  (0.7 ml) and THF (0.7 ml),  $\text{NaNO}_2$  (12 mg, 0.17 ml) and 90% aqueous AcOH (0.06 ml) were added at  $0^\circ\text{C}$  and the mixture was stirred at  $0^\circ\text{C}$  for 3h. After dilution with  $\text{CH}_2\text{Cl}_2$  (5 ml), the organic layer was washed with water (1 ml), dried over sodium sulphate and concentrated *in vacuo*. The residue was purified by flash column chromatography ( $\text{SiO}_2$ , hexane:ethyl acetate 2:1) to afford **Int-25** (9.8 mg, 50%) as a white solid.

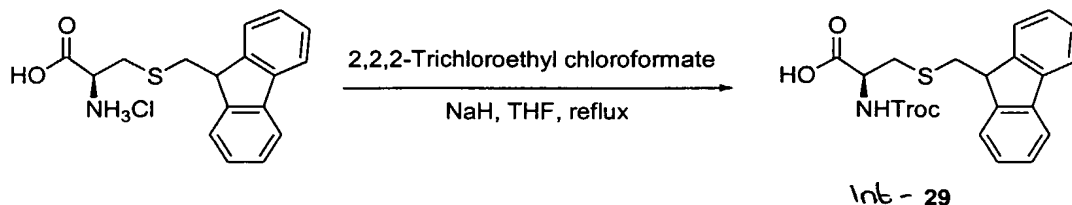
Rf: 0.34 (hexane:ethyl acetate 1:1).

$^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.71 (s, 1H), 6.11 (m, 1H), 5.92 (d,  $J = 1.5$  Hz, 1H), 5.87 (d,  $J = 1.5$  Hz, 1H), 5.42 (dq,  $J_1 = 1.5$  Hz,  $J_2 = 17.1$  Hz, 1H), 5.28 (dq,  $J_1 = 1.5$  Hz,  $J_2 = 10.2$  Hz, 1H), 5.12 (s, 2H), 4.26-4.09 (m, 3H), 4.05 (d,  $J = 2.4$  Hz, 1H), 3.97 (t,  $J = 3.0$  Hz, 1H), 3.70 (s, 3H), 3.67-3.32 (m, 4H), 3.58 (s, 3H), 3.24 (dd,  $J_1 = 2.7$  Hz,  $J_2 = 15.9$  Hz, 1H), 3.12 (dd,  $J_1 = 8.1$  Hz,  $J_2 = 18.0$  Hz, 1H), 2.51 (d,  $J = 18$  Hz, 1H), 2.36 (s, 3H), 2.21 (s, 3H), 2.12 (s, 3H), 1.83 (dd,  $J_1 = 12.3$  Hz,  $J_2 = 15.9$  Hz, 1H).

$^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ )  $\delta$  148.7, 148.4, 138.9, 133.7, 131.1, 129.4, 125.1, 123.9, 120.7, 117.6, 117.5, 113.2, 112.3, 101.1, 99.2, 74.0, 63.2, 59.8, 59.7, 57.9, 57.7, 57.0, 56.5, 55.2, 41.6, 29.6, 26.1, 25.6, 22.6, 15.7, 9.2.

ESI-MS  $m/z$ : Calcd. for  $\text{C}_{31}\text{H}_{37}\text{N}_3\text{O}_7$ : 563.64. Found  $(\text{M}+\text{H})^+$ : 564.1.

## Example 29

Compound **Int-29**

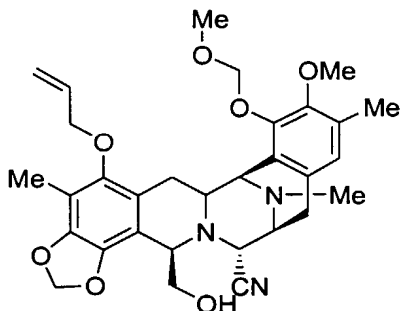
The starting material (2.0 g, 5.90 ml) was added to a suspension of sodium hydride (354 mg, 8.86 ml) in THF (40 ml) at 23 °C, following the suspension was treated with allyl chloroformate (1.135 ml, 8.25 ml) at 23 °C and then refluxed for 3 hours. The suspension was cooled, filtered off, the solid washed with ethyl acetate (100 ml), and the filtrate was concentrated. The oil crude was ground with hexane (100 ml) and kept at 4°C overnight. After, the solvent was decanted and the light yellow slurry was treated with CH<sub>2</sub>Cl<sub>2</sub> (20 ml), and precipitated with hexane (100 ml). After 10 minutes, the solvent was decanted again. The operation was repeated until appearing a white solid. The white solid was filtered off and dried to afford compound **Int-29** (1.80 g, 65%) as a white solid.

<sup>1</sup>H-NMR (300 MHz, CDCl<sub>3</sub>): δ 7.74 (d, *J*= 7.5 Hz, 2H), 7.62 (d, *J*= 6.9 Hz, 2H), 7.33 (t, *J*= 7.5 Hz, 2H), 7.30 (t, *J*= 6.3 Hz, 2H), 5.71 (d, *J*= 7.8 Hz, 1H), 4.73 (d, *J*= 7.8 Hz, 2H), 4.59 (m, 1H), 4.11 (t, *J*= 6.0 Hz, 1H), 3.17 (dd, *J*= 6.0 Hz, *J*= 2.7 Hz, 2H), 3.20 (dd, *J*= 5.4 Hz, *J*= 2.1 Hz, 2H).

<sup>13</sup>C-NMR (75 MHz, CDCl<sub>3</sub>): δ 173.6, 152.7, 144.0, 139.7, 137.8, 126.0, 125.6, 123.4, 118.3, 73.4, 52.4, 45.5, 35.8, 33.7.

ESI-MS *m/z*: Calcd.. for C<sub>20</sub>H<sub>18</sub>Cl<sub>3</sub>NO<sub>4</sub>S: 474.8. Found (M+Na)<sup>+</sup>: 497.8

## Example 30

Compound **Int-30**

A mixture of compound **Int-25** (585 mg, 1.03 ml) and compound **Int-29** (1.47 mg, 3.11 ml) were azeotroped with anhydrous toluene (3 x 10 ml). To a solution of **Int-25** and **Int-29** in anhydrous  $\text{CH}_2\text{Cl}_2$  (40 ml) was added DMAP (633 mg, 5.18 ml) and EDC·HCl (994 mg, 5.18 ml) at 23 °C. The reaction mixture was stirred at 23 °C for 3 hours. The mixture was partitioned with saturated aqueous solution of sodium bicarbonate (50 ml) and the layers were separated. The aqueous layer was washed with  $\text{CH}_2\text{Cl}_2$  (50 ml). The combined organic layers were dried over sodium sulphate, filtered and concentrated. The crude was purified by flash column chromatography (ethyl acetate/hexane 1:3) to obtain **Int-30** (1.00 g, 95%) as a pale cream yellow solid.

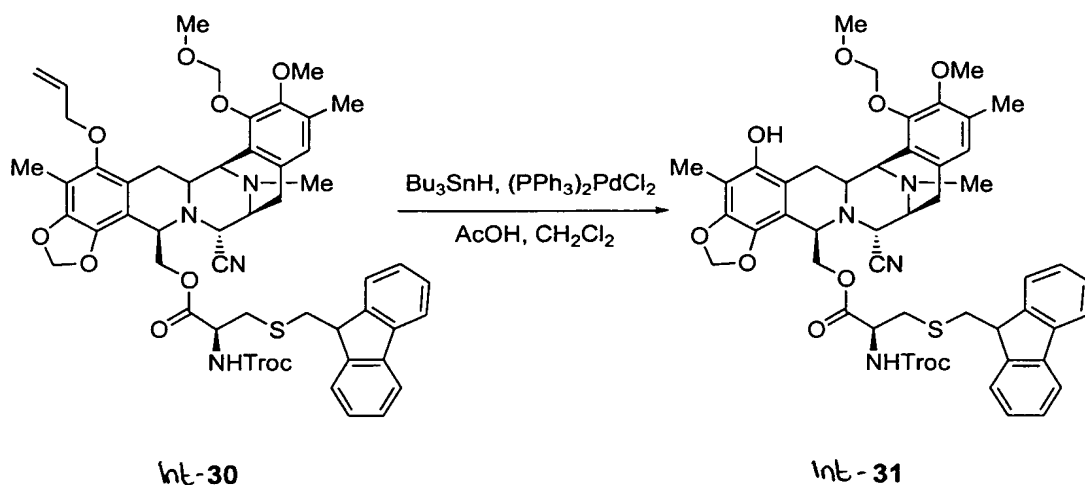
$^1\text{H}$ -NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.72 (m, 2H), 7.52 (m, 2H), 7.38 (m, 2H), 7.28 (m, 2H), 6.65 (s, 1H), 6.03 (m, 1H), 5.92 (d,  $J$  = 1.5 Hz, 1H), 5.79 (d,  $J$  = 1.5 Hz, 1H), 5.39 (m, 1H), 5.29 (dq,  $J$  = 10.3 Hz,  $J$  = 1.5 Hz, 1H), 5.10 (s, 2H), 4.73 (d,  $J$  = 11.9 Hz, 1H), 4.66 (d,  $J$  = 11.9 Hz, 1H), 4.53 (m, 1H), 4.36-3.96 (m, 9H), 3.89 (t,  $J$  = 6.4 Hz, 1H), 3.71 (s, 3H), 3.55 (s, 3H), 3.33 (m, 1H), 3.20 (m, 2H), 2.94 (m, 3H), 2.59 (m, 1H), 2.29 (s, 3H), 2.23 (s, 3H), 2.02 (s, 3H), 1.83 (dd,  $J$  = 16.0 Hz,  $J$  = 11.9 Hz, 1H).

$^{13}\text{C}$ -NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  169.7, 154.0, 148.8, 148.4, 145.7, 144.5, 140.9, 139.0, 133.7, 130.9, 130.6, 127.6, 127.0, 124.8, 124.6, 124.1, 120.8, 119.9, 118.2, 117.7, 117.3, 112.7, 112.1, 101.3, 99.2, 74.7, 73.9, 64.4, 59.8, 57.7, 57.0, 56.8, 55.4, 53.3, 46.7, 41.4, 36.5, 34.7, 31.5, 26.4, 24.9, 22.6, 15.7, 14.0, 9.1.

ESI-MS  $m/z$ : Calcd.. for  $\text{C}_{51}\text{H}_{53}\text{Cl}_3\text{N}_4\text{O}_{10}\text{S}$ : 1020.4. Found ( $\text{M}+\text{H}$ ) $^+$ : 1021.2



## Example 31

Compound **Int-31**

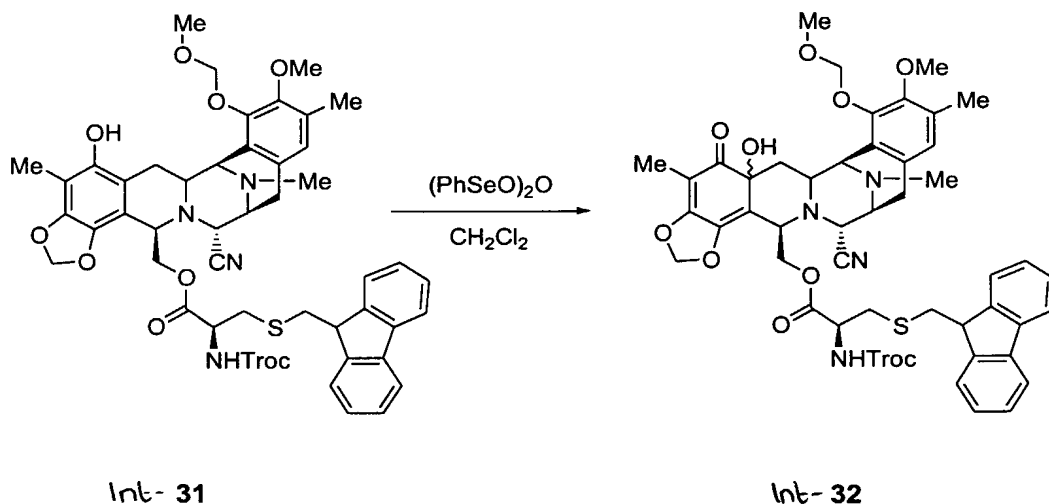
To a solution of **Int-30** (845 mg, 0.82 ml), acetic acid (500 mg, 8.28 ml) and  $(\text{PPh}_3)_2\text{PdCl}_2$  (29 mg, 0.04 ml) in anhydrous  $\text{CH}_2\text{Cl}_2$  20 ml at 23 °C was added, dropwise,  $\text{Bu}_3\text{SnH}$  (650 mg, 2.23 ml). The reaction mixture was stirred at this temperature for 15 min., bubbling was. The crude was quenched with water (50ml) and extracted with  $\text{CH}_2\text{Cl}_2$  (3 x 50 ml). The organic layers were dried over sodium sulphate, filtered and concentrated. The crude was purified by flash column chromatography (ethyl acetate/hexane in gradient from 1:5 to 1:3) to obtain compound **Int-31** (730 mg, 90%) as a pale cream yellow solid.

$^1\text{H-NMR}$  (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.72 (m, 2H), 7.56 (m, 2H), 7.37 (m, 2H), 7.30 (m, 2H), 6.65 (s, 1H), 5.89 (s, 1H), 5.77 (s, 1H), 5.74 (s, 1H), 5.36 (d,  $J = 5.9$  Hz, 1H), 5.32 (d,  $J = 5.9$  Hz, 1H), 5.20 (d,  $J = 9.0$ , 1H), 4.75 (d,  $J = 12.0$  Hz, 1H), 4.73 (m, 1H), 4.48 (d,  $J = 11.9$  Hz, 1H), 4.08 (m, 4H), 3.89 (m, 1H), 3.86 (t,  $J = 6.2$  Hz, 1H), 3.70 (s, 3H), 3.69 (s, 3H), 3.38 (m, 1H), 3.25 (m, 1H), 3.02-2.89 (m, 4H), 2.67 (s, 1H), 2.61 (s, 1H), 2.51 (dd,  $J = 14.3$  Hz,  $J = 4.5$  Hz, 1H), 2.29 (s, 3H), 2.23 (s, 3H), 1.95 (s, 3H), 1.83 (m, 1H).

$^{13}\text{C-NMR}$  (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  168.2, 152.5, 148.1, 146.2, 144.4, 144.3, 143.3, 139.6, 134.6, 129.7, 129.6, 126.2, 125.6, 123.4, 123.3, 121.6, 118.5, 116.3, 110.7, 110.2, 105.1, 99.4, 98.5, 75.2, 73.3, 61.7, 58.4, 57.9, 56.3, 56.1, 55.1, 54.7, 53.9, 51.9, 45.2, 40.1, 35.6, 33.3, 24.8, 23.3, 14.5, 7.3.

ESI-MS  $m/z$ : Calcd.. for  $\text{C}_{48}\text{H}_{49}\text{Cl}_3\text{N}_4\text{O}_{10}\text{S}$ : 980.3. Found  $(\text{M}+\text{H})^+$ : 981.2

## Example 32

Compound **Int-32**

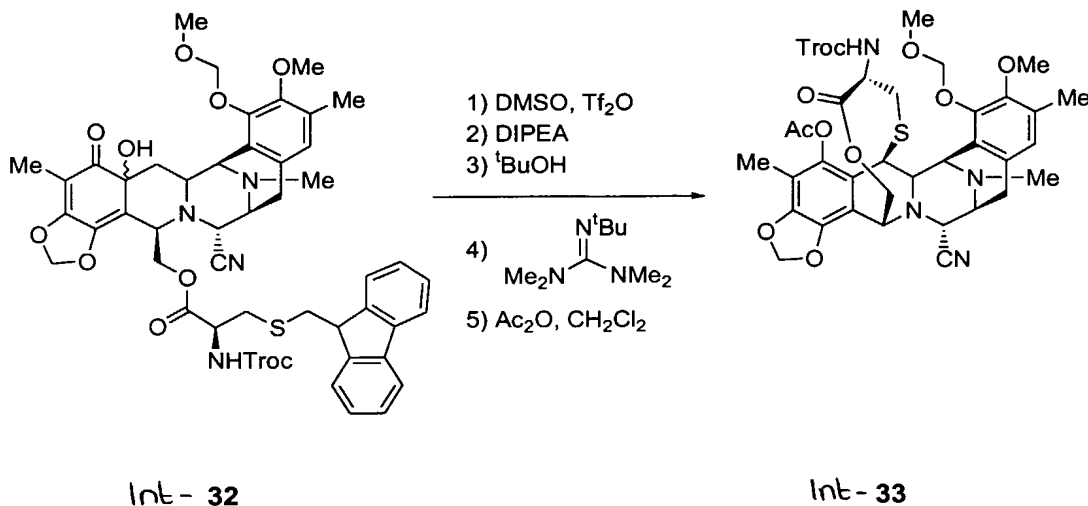
To a solution of **Int-31** (310 mg, 0.32 ml), in anhydrous  $\text{CH}_2\text{Cl}_2$  (15 ml) at  $-10^\circ\text{C}$  was added a solution of benzeneseleninic anhydride 70 % (165 mg, 0.32 ml), in anhydrous  $\text{CH}_2\text{Cl}_2$  (7 ml), *via* cannula, keeping the temperature at  $-10^\circ\text{C}$ . The reaction mixture was stirred at  $-10^\circ\text{C}$  for 5 min. A saturated solution of sodium bicarbonate (30 ml) was added at this temperature. The aqueous layer was washed with more  $\text{CH}_2\text{Cl}_2$  (40 ml). The organic layers were dried over sodium sulphate, filtered and concentrated. The crude was purified by flash column chromatography (ethyl acetate/hexane in gradient from 1:5 to 1:1) to obtain **Int-32** (287 mg, 91%, HPLC: 91.3%) as a pale cream yellow solid and as a mixture of two isomers (65:35) which were used in the next step.

$^1\text{H-NMR}$  (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  (Mixture of isomers) 7.76 (m, 4H), 7.65 (m, 4H), 7.39 (m, 4H), 7.29 (m, 4H), 6.62 (s, 1H), 6.55 (s, 1H), 5.79-5.63 (m, 6H), 5.09 (s, 1H), 5.02 (d,  $J=6.0$  Hz, 1H), 4.99 (d,  $J=6.0$  Hz, 1H), 4.80-4.63 (m, 6H), 4.60 (m, 1H), 4.50 (m, 1H), 4.38 (d,  $J=12.8$  Hz,  $J=7.5$  Hz, 1H), 4.27 (dd,  $J=12.8$  Hz,  $J=7.5$  Hz, 1H), 4.16-3.90 (m, 10H), 3.84 (s, 3H), 3.62 (s, 3H), 3.50 (s, 3H), 3.49 (s, 3H), 3.33-2.83 (m, 14H), 2.45-2.18 (m, 2H), 2.21 (s, 6H), 2.17 (s, 6H), 1.77 (s, 6H), 1.67 (m, 2H).

$^{13}\text{C}$ -NMR (75 MHz,  $\text{CDCl}_3$ ):  $\delta$  (Mixture of isomers) 168.6, 168.4, 158.6, 154.8, 152.8, 152.5, 147.3, 147.2, 146.8, 144.1, 144.0, 140.8, 139.7, 137.1, 129.8, 129.3, 128.4, 128.7, 126.5, 125.5, 123.7, 123.6, 123.5, 123.4, 122.2, 121.3, 118.3, 115.8, 115.5, 110.2, 106.9, 103.5, 103.2, 100.1, 99.6, 97.9, 97.7, 93.8, 73.4, 70.9, 69.2, 64.9, 62.5, 59.3, 58.9, 58.4, 56.7, 56.3, 56.2, 55.4, 55.2, 55.1, 54.9, 54.7, 54.3, 54.1, 53.8, 52.8, 45.5, 40.5, 40.0, 39.8, 35.8, 35.5, 33.9, 33.7, 30.1, 28.8, 24.2, 24.1, 21.2, 14.5, 14.4, 12.7, 6.0, 5.7.

ESI-MS  $m/z$ : Calcd.. for  $\text{C}_{48}\text{H}_{49}\text{Cl}_3\text{N}_4\text{O}_{11}\text{S}$ : 996.3. Found  $(\text{M}+\text{H})^+$ : 997.2

## Example 33

Compound **Int-33**

The reaction flask was flamed twice, purged vacuum/Argon several times and kept under Argon atmosphere for the reaction. To a solution of DMSO (39.1 ml, 0.55 ml, 5 equivalents.) in anhydrous  $\text{CH}_2\text{Cl}_2$  (4.5 ml) was dropwise added triflic anhydride (37.3 ml, 0.22 ml, 2 equivalents.) at  $-78^\circ\text{C}$ . The reaction mixture was stirred at  $-78^\circ\text{C}$  for 20 minutes, then a solution of **Int-32** (110 mg, 0.11 ml, HPLC: 91.3%) in anhydrous  $\text{CH}_2\text{Cl}_2$  (1 ml, for the main addition and 0.5 ml for wash) at  $-78^\circ\text{C}$  was added, *via* cannula. During the addition the temperature was kept at  $-78^\circ\text{C}$  in both flasks and the colour changed from yellow to brown. The reaction mixture was stirred at  $-40^\circ\text{C}$  for 35 minutes. During this period of time the solution was turned from yellow to dark green. After this time,  $i\text{Pr}_2\text{NEt}$  (153 ml, 0.88 ml, 8 equivalents.) was dropwise added and the reaction mixture was kept at  $0^\circ\text{C}$  for 45 minutes, the colour of the solution turned to brown during this time. Then  $t$ -butanol (41.6 ml, 0.44 ml, 4 equivalents.) and 2- $t$ -Butyl-1,1,3,3-tetramethylguanidine (132.8 ml, 0.77 ml, 7 equivalents.) were dropwise added and the reaction mixture was stirred at  $23^\circ\text{C}$  for 40 minutes. After this time, acetic anhydride (104.3 ml, 1.10 ml, 10 equivalents.) was dropwise added and the reaction mixture was kept at  $23^\circ\text{C}$  for 1 hour more. Then the reaction mixture was diluted with  $\text{CH}_2\text{Cl}_2$  (20ml) and washed with aqueous saturated solution of  $\text{NH}_4\text{Cl}$  (50ml), sodium

bicarbonate (50ml), and sodium chloride (50ml). The combined organic layers were dried over sodium sulphate, filtered and concentrated. The residue was purified by flash column chromatography (eluent: ethyl acetate/hexane gradient from 1:3 to 1:2) to afford compound **Int-33** (54 mg, 58%) as a pale yellow solid.

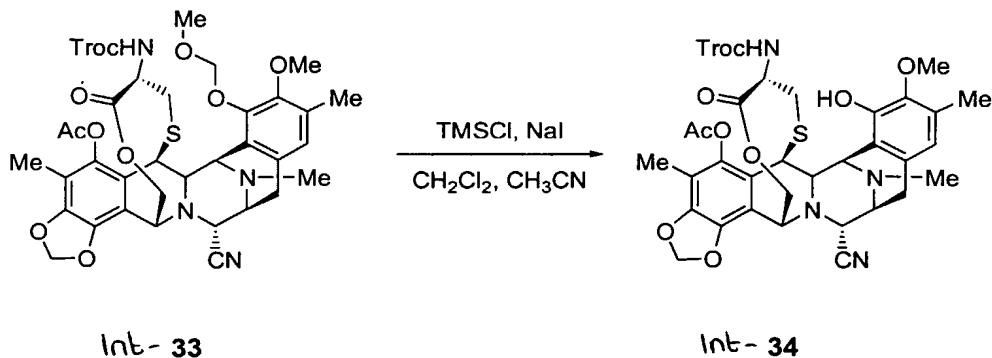
<sup>1</sup>H-NMR (300 MHz, CDCl<sub>3</sub>): δ 6.85 (s, 1H), 6.09 (s, 1H), 5.99 (s, 1H), 5.20 (d, *J*= 5.8 Hz, 1H), 5.14 (d, *J*= 5.3 Hz, 1H), 5.03 (m, 1H), 4.82 (d, *J*= 12.2, 1H), 4.63 (d, *J*= 12.0 Hz, 1H), 4.52 (m, 1H), 4.35-4.17 (m, 4H), 3.76 (s, 3H), 3.56 (s, 3H), 3.45 (m, 2H), 2.91 (m, 2H), 2.32 (s, 3H), 2.28 (s, 3H), 2.21 (s, 3H), 2.12 (m, 2H), 2.03 (s, 3H).

<sup>13</sup>C-NMR (75 MHz, CDCl<sub>3</sub>): δ 168.5, 167.2, 152.7, 148.1, 147.1, 144.5, 139.6, 139.1, 130.5, 129.0, 123.7, 123.5, 123.3, 118.8, 116.5, 112.1, 100.6, 97.8, 73.3, 60.5, 59.4, 59.2, 58.3, 57.6, 57.4, 56.1, 53.3, 53.1, 40.6, 40.0, 31.0, 22.2, 18.9, 14.4, 8.1.

ESI-MS *m/z*: Calcd.. for C<sub>36</sub>H<sub>39</sub>Cl<sub>3</sub>N<sub>4</sub>O<sub>11</sub>S: 842.1. Found (M+H)<sup>+</sup>: 843.1

### Example 34

### Compound Int-34



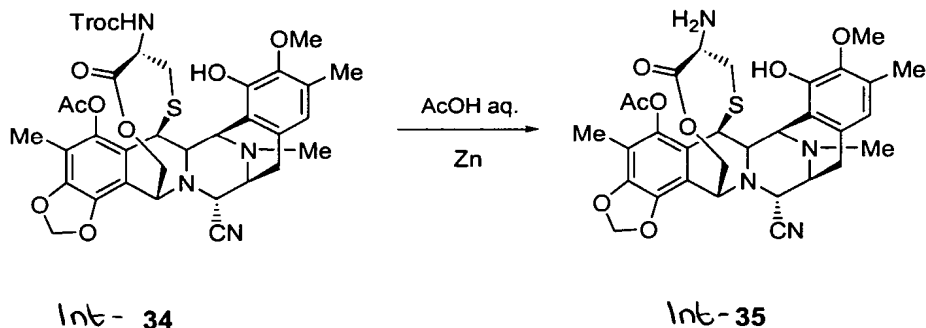
To a solution of **Int-33** (12 mg, 0.014 ml) in dry dichloromethane (1.2 ml) and HPLC grade acetonitrile (1.2 ml) was added at 23 °C sodium iodide (21 mg, 0.14 ml) and freshly distilled (over calcium hydride at atmospheric pressure) trimethylsilyl chloride (15.4 mg, 0.14 ml). The reaction mixture turned to orange colour. After 15 min the solution was diluted with dichloromethane (10 ml) and was washed with a freshly aqueous saturated solution of Na<sub>2</sub>S<sub>2</sub>O<sub>4</sub> (3 x 10 ml). The organic layer was dried over sodium sulphate, filtered and concentrated. It was obtained compound **Int-34** (13 mg, quantitative) as pale yellow solid which was used without further purification.

<sup>1</sup>H-NMR (300 MHz, CDCl<sub>3</sub>): δ 6.85 (s, 1H), 6.09 (s, 1H), 5.99 (s, 1H), 5.27 (d, *J* = 5.8 Hz, 1H), 5.14 (d, *J* = 5.3 Hz, 1H), 5.03 (d, *J* = 11.9 Hz, 1H), 4.82 (d, *J* = 12.2, 1H), 4.63 (d, *J* = 13.0 Hz, 1H), 4.52 (m, 1H), 4.34 (m, 1H), 4.27 (bs, 1H), 4.18 (m, 2H), 3.76 (s, 3H), 3.56 (s, 3H), 3.44 (m, 1H), 3.42 (m, 1H), 2.91 (m, 2H), 2.32 (s, 3H), 2.28 (s, 3H), 2.21 (s, 3H), 2.03 (s, 3H).

ESI-MS m/z: Calcd.. for  $C_{34}H_{35}N_4O_{10}S$ : 798.1. Found  $(M+H)^+$ : 799.1

### Example 35

### Compound Int-35



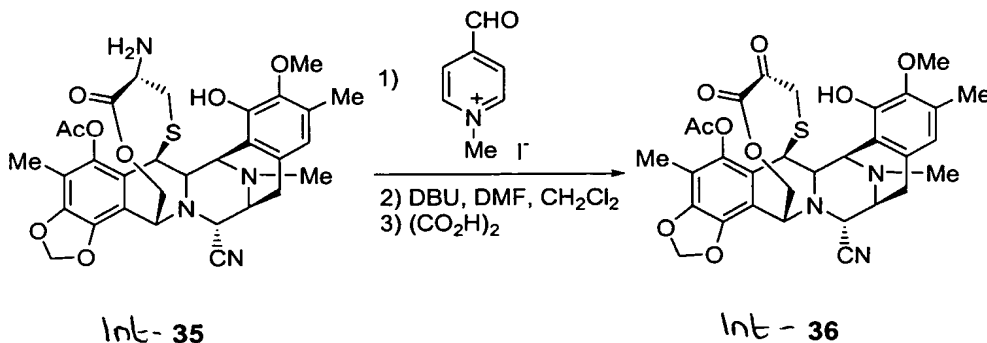
To a solution of **Int-34** (13 mg, 0.016 ml) in a mixture of acetic acid/H<sub>2</sub>O (90:10, 1 ml) was added powder Zinc (5.3 mg, 0.081 ml) at 23 °C. The reaction mixture was heated at 70 °C for 6 h. After this time, was cooled to 23 °C, diluted with CH<sub>2</sub>Cl<sub>2</sub> (20 ml) and washed with aqueous saturated solution of sodium bicarbonate (15 ml) and aqueous solution of Et<sub>3</sub>N (15 ml). The organic layer was dried over sodium sulphate, filtered and concentrated. The residue was purified by flash column chromatography with Silica-NH<sub>2</sub> (eluent: ethyl acetate/hexane gradient from 0:100 to 50:50) to afford compound **Int-35** (6.8 mg, 77% for two steps) as a pale yellow solid.

<sup>1</sup>H-NMR (300 MHz, CDCl<sub>3</sub>): δ 6.51 (s, 1H), 6.03 (dd, *J* = 1.3 Hz, *J* = 26.5 Hz, 2H), 5.75 (bs, 1H), 5.02 (d, *J* = 11.6 Hz, 1H), 4.52 (m, 1H), 4.25 (m, 2H), 4.18 (d, *J* = 2.5 Hz, 1H), 4.12 (dd, *J* = 1.9 Hz, *J* = 11.5 Hz, 1H), 3.77 (s, 3H), 3.40 (m, 2H), 3.26 (t, *J* = 6.4 Hz, 1H), 2.88 (m, 2H), 2.30-2.10 (m, 2H), 2.30 (s, 3H), 2.28 (s, 3H), 2.18 (s, 3H), 2.02 (s, 3H).

<sup>13</sup>C-NMR (75 MHz, CDCl<sub>3</sub>): δ 174.1, 168.4, 147.8, 145.4, 142.9, 140.8, 140.1, 131.7, 130.2, 129.1, 128.3, 120.4, 118.3, 117.9, 113.8, 111.7, 101.7, 61.2, 59.8, 59.2, 58.9, 54.4, 53.8, 54.4, 41.3, 41.5, 34.1, 23.6, 20.3, 15.5, 9.4.

ESI-MS  $m/z$ : Calcd.. for  $C_{31}H_{34}N_4O_8S$ : 622.7. Found  $(M+H)^+$ : 623.2.

## Example 36

Compound **Int-36**

A solution of N-methyl pyridine-4-carboxaldehyde iodide (378 mg, 1.5 mmol) in anhydrous DMF (5.8 mL) was treated with anhydrous toluene (2 x 10 mL) to eliminate the amount of water by azeotropic removal of the toluene. A solution of 35 (134 mg, 0.21 mmol), previously treated with anhydrous toluene (2 x 10 mL), in anhydrous CH<sub>2</sub>Cl<sub>2</sub> (distilled over CaH<sub>2</sub>, 7.2 mL) was added, via cannula, at 23 °C to this orange solution. The reaction mixture was stirred at 23 °C for 4 hours. After this time DBU (32.2 L, 0.21mmol) was dropwise added at 23 °C and it was stirred for 15 minutes at 23 °C. A freshly aqueous saturated solution of oxalic acid (5.8 mL) was added to the reaction mixture and was stirred for 30 minutes at 23 °C. Then the reaction mixture was cooled to 0 °C and NaHCO<sub>3</sub> was portionwise added followed by addition of aqueous saturated solution of NaHCO<sub>3</sub>. The mixture was extracted with Et<sub>2</sub>O. K<sub>2</sub>CO<sub>3</sub> was added to the aqueous layer and it was extrated with Et<sub>2</sub>O. The combined organic layers were dried over MgSO<sub>4</sub> and the solvent was removed under reduced pressure. The crude was purified by flash column chromatography (AcOEt/hexane from 1/3 to 1/1) to afford compound 36 (77 mg, 57%) as pale yellow solid. <sup>1</sup>H-NMR (300 MHz, CDCl<sub>3</sub>): 6.48 (s, 1H), 6.11 (d, J= 1.3 Hz, 1H), 6.02 (d, J= 1.3 Hz, 1H), 5.70 (bs, 1H), 5.09 (d, J= 11.3 Hz, 1H), 4.66 (bs, 1H), 4.39 (m, 1H), 4.27 (d, J= 5.6 Hz, 1H), 4.21 (d, J= 10.5 Hz, 1H), 4.16 (d, J= 2.6 Hz, 1H), 3.76 (s, 3H), 3.54 (d, J= 5.1 Hz, 1H), 3.42 (d, J= 8.5 Hz, 1H), 2.88-2.54 (m, 3H), 2.32 (s, 3H), 2.24 (s, 3H), 2.14 (s, 3H), 2.04 (s, 3H). <sup>13</sup>C-NMR (75 MHz, CDCl<sub>3</sub>): 186.7, 168.5, 160.5, 147.1, 146.4, 142.9, 141.6, 140.7, 130.4, 129.8,



121.7 (2C), 120.0, 117.8, 117.1, 113.5, 102.2, 61.7, 61.4, 60.3, 59.8, 58.9, 54.6, 41.6, 36.9, 29.7, 24.1, 20.3, 15.8, 14.1, 9.6. ESI-MS  $m/z$ : Calcd.. for  $C_{31}H_{31}N_3O_9S$ : 621.7. Found (M+H)<sup>+</sup>: 622.2.

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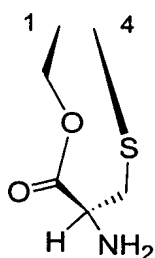
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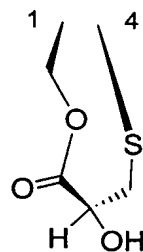
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## CLAIMS

1. A compound having a fused ecteinascidin five ring system with a 1,4 bridge having the structure of formula (VIa or VIb):



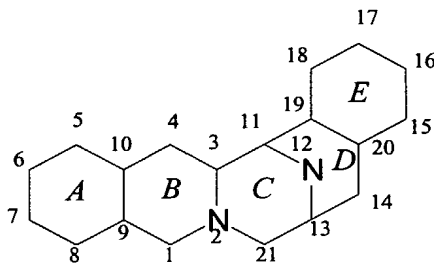
VIa



VIb

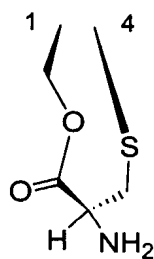
and compounds in which the  $\text{-NH}_2$  or  $\text{-OH}$  of the 1,4 bridge is derivatised; with the exception of ecteinascidin 583 or 597, and with the exception of compounds 14, 15 or 47 of U.S. Patent No 5,721,362.

2. A compound according to claim 1, wherein the fused ecteinascidin five ring system is as in the ecteinascidins, the ring system being of the formula (XIV):

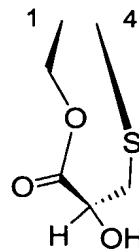


Where the rings A and E are phenolic; the rings B and D are tetrahydro, and ring C is perhydro.

3. A compound according to claim 2, wherein substituents at positions 5, 6, 7, 8, 12, 16, 17, 18 and 21 are as in a known ecteinascidin.
4. A compound according to claim 3, wherein the substituents at positions 5, 6, 7, 8, 12, 16, 17 and 18 are as in a known ecteinascidin.
5. A compound according to claim 3 or 4, wherein the known ecteinascidin is ecteinascidin 743.
6. A compound according to any preceding claim, wherein the  $\text{-NH}_2$  or  $\text{-OH}$  of the 1,4 bridge is derivatised.
7. A compound according to claim 6, in which the group  $\text{-CHNH}_2\text{-}$  in the 1,4 bridge is replaced by a group  $\text{-C(X}_2\text{)}_2\text{-}$ , where  $\text{X}_2$  is  $\text{OX}_1$  or  $\text{N(X}_1\text{)}_2$  wherein the or each  $\text{X}_1$  is independently H,  $\text{C(=O)R'}$ , substituted or unsubstituted  $\text{C}_1\text{-C}_{18}$  alkyl, substituted or unsubstituted  $\text{C}_2\text{-C}_{18}$  alkenyl, substituted or unsubstituted  $\text{C}_2\text{-C}_{18}$  alkynyl, substituted or unsubstituted aryl, or two  $\text{X}_1$  groups may together form a cyclic substituent on the nitrogen atom.
8. A pharmaceutical composition comprising a compound having a fused ecteinascidin five ring system with a 1,4 bridge having the structure of formula (VIa or VIb):



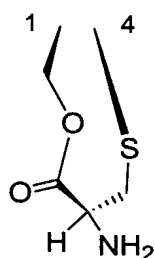
VIa



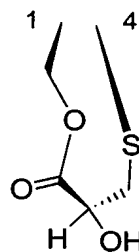
VIb

and compounds in which the  $\text{-NH}_2$  or  $\text{-OH}$  of the 1,4 bridge is derivatised; with the exception of ecteinascidin 583 or 597, together with a pharmaceutically acceptable carrier.

9. The use of a compound having a fused ecteinascidin five ring system with a 1,4 bridge having the structure of formula (VIa or VIb):



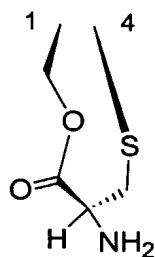
VIa



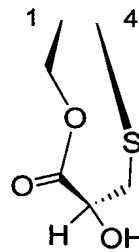
VIb

and compounds in which the  $\text{-NH}_2$  or  $\text{-OH}$  of the 1,4 bridge is derivatised; with the exception of ecteinascidin 583 or 597, in the preparation of a medicament for use in the treatment of a tumour.

10. A method of treating a tumour which comprises administration of an effective amount of a compound having a fused ecteinascidin five ring system with a 1,4 bridge having the structure of formula (VIa or VIb):



VIa



VIb

and compounds in which the  $\text{-NH}_2$  or  $\text{-OH}$  of the 1,4 bridge is derivatised; with the exception of ecteinascidin 583 or 597.

# INTERNATIONAL SEARCH REPORT

International Application No  
PCT/GB 01/01667

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 C07D515/22 A61K35/00 A61K35/56 //(C07D515/22,317:00,  
291:00,241:00,221:00,221:00)

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 C07D A61K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, CHEM ABS Data

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 721 362 A (COREY ELIAS J ET AL) 24 February 1998 (1998-02-24) cited in the application claims 1,29-31; examples 14,1547	1,7,9
X	E.J.COREY,DAVID Y.GIN, AND ROBERT S. KANIA: "Enantioselective Total Synthesis of Ecteinascidin" J.AM.CHEM.SOC., vol. 118, 1996, pages 9202-9203, XP002925428 page 203; examples 14,15; table 1A --- -/--	1,7

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

### \* Special categories of cited documents :

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
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- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

- \*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- \*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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- \*&\* document member of the same patent family

Date of the actual completion of the international search

4 July 2001

Date of mailing of the international search report

11/07/2001

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Goss, I

## INTERNATIONAL SEARCH REPORT

Int. Application No.

PCT/GB 01/01667

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	RYUICHI SAKAI ET AL.: "Ecteinascidins: Putative Biosynthetic Precursors and Absolute Stereochemistry" J.AM.CHEM.SOC., vol. 118, 1996, pages 9017-9023, XP002925426 page 9023, left-hand column, paragraph 1; examples 1-4 ---	1,7
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Information on patent family members

International Application No

PCT/GB 01/01667

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		JP 2001501196 T	30-01-2001
		NO 991301 A	14-05-1999
		PL 332206 A	30-08-1999
		WO 9812198 A	26-03-1998
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